PB90-234303

# Best Demonstrated Available Technology (BDAT) Background Document for U and P Wastes and Multisource Leachates. Volume D Reactive U and P Wastewaters and Nonwastewaters

Versar, Inc., Springfield, VA

Prepared for:

Environmental Protection Agency, Washington, DC

May 90

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

| REPORT DOCUMENTATION PAGE | 1. REPORT NO. EPA/530-SW-90-060C | 2. | 3. PB90-234303 |
|---|---|---|---|
| 4. Title and Subtitle<br>FINAL BDAT BACK. DOCU. FOR U AND P WASTES & MULTISOURCE LEACHATES VOL. D: REACTIE U & P WASTEWATERSA ND NONWASTEWATERS | | | 5. Report Date<br>MAY 1990<br>6. |
| 7. Author(s)<br>KINCH/FARGO/OSW | | | 8. Performing Organization Rept. No |
| 9. Performing Organization Name and Address<br>U.S. EPA<br>Office of Solid Waste<br>401 M. Street SW<br>Washington, DC 20460 | | | 10. Project/Task/Work Unit No.<br>11. Contract(C) or Grant(G) No.<br>(C)<br>(G) |
| 12. Sponsoring Organization Name and Address | | | 13. Type of Report & Period Covered<br>BACK. DOCU. 5/90<br>14. |

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This background document provides the Agency's rationale and technical support for developing treatment standards for those U and P wastes with reactive listing constituents. These standards are applicable to the wastes as listed in 40 CFR 261.33(e) and (f) as well as to any wastes generated by the management or treatment of the listed waste.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

| 18. Availability Statement | 19. Security Class (This Report) | 21. No. of Pages |
|---|---|---|
| | UNCLASSIFIED | 84 |
| RELEASE UNLIMITED | 20. Security Class (This Page) UNCLASSIFIED | 22. Price 0 |

(See ANSI-Z39.18)

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)

EPA/530-SW-90-060C
PB90-234303

# FINAL
# BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR

# U AND P WASTES AND MULTISOURCE LEACHATES
# VOLUME D:
# REACTIVE U & P WASTEWATERS AND NONWASTEWATERS

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May 1990

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# 1. INTRODUCTION

## 1.1 Regulatory Background

Section 3004(m) of the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) on November 8, 1984, requires the U.S. Environmental Protection Agency (EPA or the Agency) to promulgate treatment standards for certain hazardous wastes based on the Best Demonstrated Available Technology (BDAT) for those wastes. More than 500 of these hazardous wastes were listed as of December 1988 (see Title 40, Code of Federal Regulations, Part 261 (40 CFR Part 261)). The Agency divided the listed hazardous wastes into five groups. The wastes in each group were examined to determine whether further land disposal is protective of human health and the environment (see 40 CFR Part 268). The five groups and their respective dates of promulgation of treatment standards are:

- Solvent and dioxin wastes — November 7, 1986
- "California List" wastes — July 8, 1987
- "First Third" wastes — August 8, 1988
- "Second Third" wastes — June 8, 1989
- "Third Third" wastes — On or before May 8, 1990

Several wastes included in this schedule were regulated ahead of schedule, and several wastes in the First Third or Second Third group of wastes were deferred to the Third Third group of wastes. Treatment standards for the Third Third wastes become effective on May 8, 1990. On and after this date, wastes regulated in the Third Third rulemaking will have to comply with applicable treatment standards prior to "land disposal" as it is defined in 40 CFR Part 268.

This background document provides the Agency's rationale and technical support for developing treatment standards for those U and P wastes with reactive listing constituents. These standards are

applicable to the wastes as listed in 40 CFR 261.33(e) and (f) as well as to any wastes generated by the management or treatment of the listed waste. Treatment standards are specified for both nonwastewater and wastewater forms of each listed hazardous waste. For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids[1] and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting the wastewater definition must comply with treatment standards for nonwastewaters.

The Agency's legal authority and promulgated methodology for establishing treatment standards and the petition process for requesting a variance from the treatment standards are summarized in EPA's Methodology for Developing BDAT Treatment Standards (Reference 1).

U wastes include discarded commercial chemical products, manufacturing chemical intermediates, off-specification commercial chemical products, container and inner liner residues, and spill cleanup residues, including contaminated water, soil, or debris, that are identified as toxic wastes. P wastes include discarded commercial chemical products, manufacturing chemical intermediates, off-specification commercial chemical products, container and inner liner residues, and spill cleanup residues, including contaminated water, soil, or debris, that are identified as acutely hazardous wastes. Section 2 discusses the definition of U and P wastes in greater detail.

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[1] The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids are measured by Method 209c (Total Suspended Solids Dried at 103°C to 105°C) in Standard Methods for the Examination of Water and Wastewater (Reference 2).

## 1.2 User's Guide to the Five-Volume U and P Waste and Multisource Leachate Background Document Set

In the interest of clarity, the Agency has reorganized the Third Third background documents that were prepared for proposal of the Third Third Rule. Multisource leachates and the majority of the U and P waste codes addressed in the Third Third Proposed Rule are now covered in a five-volume set of background documents.

The five-volume background document set is organized as follows:

- Volume A - Wastewater forms of organic U and P wastes and multisource leachates with concentration-based treatment standards;
- Volume B - U and P wastewaters and nonwastewaters with methods of treatment as treatment standards;
- Volume C - Nonwastewater forms of organic U and P wastes and multisource leachates with concentration-based treatment standards;
- Volume D (this document) - Reactive U and P wastewaters and nonwastewaters; and
- Volume E - Gases.

## 1.3 Summary of Contents: Volume D

This background document provides the Agency's rationale and technical support for developing treatment standards for the reactive U and P wastes. These wastes pose a significant risk during handling because of their reactivity. The hazardous wastes with hazardous waste codes beginning with P are identified as acute hazardous waste, while the hazardous waste codes beginning with U identify toxic wastes. Whether a waste is an acute hazardous waste or a toxic waste generally has no bearing on the treatability of the waste. The following is the list of P and U wastes containing reactive listing constituents:

P006 - Aluminum phosphide
P009 - Ammonium picrate
P015 - Beryllium dust
P056 - Fluorine
P068 - Methyl hydrazine
P073 - Nickel carbonyl
P081 - Nitroglycerine
P087 - Osmium tetroxide
P096 - Phosphine
P105 - Sodium azide
P112 - Tetranitromethane
P122 - Zinc phosphide (>10%)

U023 - Benzotrichloride
U086 - 1,2-Diethylhydrazine
U096 - a,a-Dimethylbenzylhydroperoxide
U098 - 1,1-Dimethylhydrazine
U099 - 1,2-Dimethylhydrazine
U103 - Dimethyl sulfate
U109 - Diphenylhydrazine
U134 - Hydrogen fluoride
U133 - Hydrazine
U135 - Hydrogen sulfide
U160 - Methyl ethyl ketone peroxide
U189 - Phosphoric sulfide
U249 - Zinc phosphide (<10%)

It should be mentioned that strontium sulfide (P107) was a reactive listing constituent. However, the Agency is not regulating P107 because on October 31, 1988, it was removed from Appendix VIII of Part 261, the list of RCRA hazardous constituents. EPA took this action because strontium sulfide, even when improperly treated, stored, transported, disposed of, or otherwise managed, does not pose a significant hazard to human health or the environment.

However, wastes containing strontium sulfide are not released from regulatory control under RCRA. If a waste contains high concentrations of strontium sulfide, it may exhibit the characteristic of reactivity (40 CFR 261.23(a)(5)) (i.e., a sulfide-bearing waste that, when exposed to pH conditions between 2 and 12.5, can generate toxic gases (e.g., $H_2S$), vapors, or fumes in a quantity sufficient to present a danger to human health or the environment). If the wastes exhibit the characteristic of reactivity, they must be handled as D003 - sulfide characteristic hazardous wastes.

# 2. WASTE CHARACTERIZATION, INDUSTRIES AFFECTED, AND ANALYTICAL ISSUES

This section describes the available waste characterization data for the P and U wastes containing reactive listing constituents, the processes generating these wastes, the industries affected by the land disposal restrictions, and analytical issues associated with these wastes.

## 2.1 Waste Characterization

According to 40 CFR 261.33, the P and U codes presented above are essentially commercial chemical products (or intermediates) and become hazardous wastes when they are discarded or are intended to be discarded; when they are mixed with waste oil, used oil, or another material; when they are applied to the land for dust suppression or road treatment; when they are otherwise applied to the land in lieu of their original intended use or when they are contained in products that are applied to the land in lieu of their original intended use; or when, in lieu of their original intended use, they are produced for use as (or as a component of) a fuel, distributed for use as a fuel, or burned as a fuel.

These materials can be present in different forms:

- Any commercial or off-specification commercial chemical product (or intermediate) with any of the above generic names;
- Residues remaining in containers that held any of the above-mentioned products (or intermediates); or
- The residue of contaminated soil, water, or other debris that results when there is a cleanup of a commercial product (or intermediate) or off-specification commercial chemical product (or intermediate) or manufacturing chemical intermediate having the generic name of any of the above-listed products that had been spilled onto the land or into the water.

Since the Agency could not characterize every P and U waste stream that could possibly be generated, the Agency has based its BDAT

development on the characteristics of the pure chemical that was listed. Below are descriptions of the pure applicable chemical elements or compounds. The waste codes are listed next to the chemical names; however, these descriptions may not always be indicative of the different P and U wastes containing the reactive chemicals that could be generated. The chemical structures of each listing constituent are shown in Table A-1 located in Appendix A. Where noted, the wastes have been listed for their reactivity. All the wastes react violently in some way, but not all are listed for reactivity. A brief statement about why each waste has been listed is also presented below.

P006 - Aluminum phosphide: This compound exists as dark gray or dark yellow crystals with a cubic zinc blend structure. It must be protected from moist air since it reacts readily to produce phosphine, which is highly toxic. It does not melt or decompose thermally at temperatures up to 1000°C. When water and acid are added to aluminum phosphide, phosphine is produced in quantitative yields. The waste is listed for reactivity and toxicity.

P009 - Ammonium picrate: This compound exists as bright yellow bitter scales or orthorhombic crystals. It explodes easily from heat or shock and is soluble in water at 20°C. The waste is listed for reactivity.

P015 - Beryllium dust: This compound exists as a gray metal with a close-packed hexagonal structure. Beryllium has a melting point of 1287°C and a boiling point of 2500°C. The dust or amalgamated metal reacts with hydrochloric acid, dilute sulfuric acid, and dilute nitric acid and reacts violently with strong bases. In both cases, it causes an evolution of hydrogen. Death may result from short exposure to very low concentrations of the dust or its salts.

P056 - Fluorine: This halogen exists as $F_2$ in its elemental state and is a pale yellow gas. Fluorine has a melting point of -219.61°C and a boiling point of -188.13°C. Fluorine is the most reactive nonmetal, and it reacts vigorously with most oxidizable substances at room temperature, frequently with ignition. Its violent reactions with organic compounds usually disintegrate the metal. This gas is dangerous to inhale.

P068 - Methyl hydrazine: This compound exists as a clear liquid with an odor that is characteristic of short chain, organic amines. It has a flash point of 70°C and an ignition temperature of 196°C. The vapors may explode and self-ignite in and on

contact with oxidizing agents. The chemical is soluble in hydrocarbons. Methyl hydrazine is considered a mild alkaline base and a strong reducing agent. It ignites spontaneously on contact with strong oxidizing agents such as fluorine, chlorine trifluoride, nitrogen tetroxide, and fuming nitric acid.

P073 - Nickel carbonyl: This chemical is a colorless, volatile liquid at standard temperature and pressure. It is extremely poisonous. It oxidizes in the air and explodes at about 60°C. Nickel carbonyl is made by passing carbon monoxide over finely divided nickel.

P081 - Nitroglycerin: This chemical exists as a pale yellow, oily liquid that explodes on rapid heating or on concussion. It crystallizes in two forms and begins to decompose at 50° to 60°C. Nitroglycerin is appreciably volatile at 100°C, evolves nitrous yellow vapors at 135°C, and explodes at 281°C. On explosion, harmless gases (i.e., oxygen, nitrogen, carbon dioxide) are produced. The waste is listed for reactivity and toxicity.

P087 - Osmium tetroxide: The form of this compound is a pale yellow solid. It exists as monoclinic crystals. Osmium tetroxide has a boiling point of 130°C and begins to sublime and distill well below the boiling point. It is soluble in benzene. The vapor is extremely poisonous. This compound is a strong oxidant.

P096 - Phosphine: This chemical compound is a poisonous gas at standard temperature and pressure. It is prepared from white phosphorus and aqueous alkali hydroxide and also by treatment of $PH_4I$ with KOH. This gas is spontaneously flammable in air if there is a trace of $P_2H_4$ present and burns with a luminous flame. Phosphine is slightly soluble in water and combines violently with oxygen and the halogens. It liberates hydrogen and forms the phosphide when passed over heated metal and forms phosphonium salts when brought into contact with the halogen acids.

P105 - Sodium azide: This compound exists as crystals that decompose into sodium and nitrogen when heated. It is soluble in water at 10°C and in alcohol at 25°C. Sodium azide can react with lead and its compounds to form explosive chemicals.

P112 - Tetranitromethane: This compound exists as a pale yellow liquid. It is insoluble in water and freely soluble in alcohol. It attacks iron, copper, brass, zinc, and rubber. Tetranitromethane can be decomposed by an alcoholic solution of potassium hydroxide. It is used as a powerful oxidizing agent. It has a boiling point of 126°C and is highly explosive in the presence of impurities. The waste is listed for reactivity.

P122 - Zinc phosphide: The chemical exists as dark gray, tetragonal crystals and powder. The chemical has a faint phosphorus odor. When heated with the exclusion of air, it melts and finally sublimes. The melting point has been given as 420°C and the boiling point as 1100°C. When kept dry, it is quite stable. It is insoluble in water and alcohol, but soluble in benzene and carbon disulfide, causing the evolution of spontaneously flammable phosphine. It reacts violently with concentrated sulfuric acid and other oxidizing agents. The waste is listed for reactivity and toxicity.

U023 - Benzotrichloride: Benzotrichloride exists as an unstable liquid that fumes in air and hydrolyzes in the presence of moisture, forming benzoic and hydrochloric acids. It is insoluble in water but soluble in alcohol, benzene, ether, and many other organic solvents. Its boiling point is 220.8°C. The waste is listed for reactivity, corrosivity, and toxicity.

U086 - 1,2-Diethylhydrazine: This compound is soluble in alcohol and ether. It has a boiling point of 86°C. When heated to decomposition, it emits toxic fumes of $NO_x$.

U096 - a,a-Dimethylbenzylhydroperoxide: The boiling point of this compound is 100° to 101°F. This compound is an oxidizer and is listed as toxic.

U098 - 1,1-Dimethylhydrazine: This compound is a flammable, hygroscopic, mobile liquid that fumes in air and gradually turns yellow. It is corrosive to skin and has a characteristic ammoniacal odor of aliphatic hydrazines. The chemical is miscible with water, causing the evolution of heat. It is also miscible with alcohol, ether, dimethylformamide, and hydrocarbons. Its boiling point is 63.9°C.

U099 - 1,2-Dimethylhydrazine: This chemical fumes in air and gradually turns yellow. It is miscible with water with the evolution of heat. This compound is corrosive to the skin.

U103 - Dimethyl sulfate: This chemical is a colorless, oily liquid with a boiling point of about 188°C with decomposition and a flash point of 182°C. It is extremely hazardous with no warning characteristics (e.g., odor, irritation).

U109 - Diphenylhydrazine: The form of this compound is yellow crystals with a melting point of 34.5°C. It is insoluble in water and freely soluble in alcohol and ether.

U133 - Hydrazine: Hydrazine exists as a colorless, oily liquid that fumes in air. It has a penetrating odor resembling that of ammonia. Hydrazine is a violent poison that causes delayed eye irritation.

It burns with violet flame and explodes during distillation if traces of air are present (also affected by ultraviolet light and metal ion catalysts). Its flash point is 126°F (52°C). Hydrazine can be stored for years if sealed in glass and kept in a cool, dark place. It forms salts with inorganic acids. The chemical is a highly polar solvent and powerful reducing agent. It dissolves many inorganic substances and is miscible with water, methyl, ethyl, propyl, and isobutyl alcohols. Hydrazine forms an azeotropic mixture with water. The waste is listed for reactivity and toxicity.

U134 - Hydrogen fluoride: Hydrogen fluoride is a colorless gas that fumes in air. It is listed as highly irritating, corrosive, and poisonous. In aqueous solutions, it is a weak acid. Its boiling point is -56°C.

U135 - Hydrogen sulfide: This chemical is a flammable, poisonous gas with a characteristic odor of rotten eggs that is perceptible in air in a concentration of 0.002 mg/l. It burns in air with a pale blue flame. The ignition temperature is 260°C. Hydrogen sulfide has explosive limits when mixed with air. Water solutions of hydrogen sulfide are not stable; absorbed oxygen causes the formation of elemental sulfur, and the solutions become turbid rapidly. It is soluble in glycerol. In a 50-50 by volume mixture of glycerol and water, the precipitation of sulfur is retarded considerably.

U160 - Methyl ethyl ketone peroxide: The waste is listed for reactivity and toxicity. The chemical will explode when heated and is a strong oxidizer.

U189 - Phosphoric sulfide: This compound exists as light yellow, triclinic crystals with a peculiar odor. It has a melting point of 286°C to 290°C and a boiling point of 513°C to 515°C. This chemical decomposes in water, forming phosphoric acid and hydrogen sulfide. It is soluble in carbon disulfide and in aqueous solutions of alkali hydroxides. It must be kept tightly closed. The waste is listed for reactivity.

U249 - Zinc phosphide: The chemical exists as dark gray tetragonal crystals and powder. The chemical has a faint phosphorus odor. When heated with the exclusion of air, it melts and finally sublimes. The melting point has been given as 420°C and the boiling point as 1100°C. When kept dry, it is quite stable. It is insoluble in water and alcohol but soluble in benzene and carbon disulfide, causing the evolution of spontaneously flammable phosphine. It reacts violently with concentrated sulfuric acid and other oxidizing agents. The waste is listed for reactivity and toxicity.

It should be mentioned that a waste is not necessarily a P waste or a U waste if it contains one or more of the chemicals with a generic name listed in 40 CFR 261.33. In other words, the fact that a waste contains aluminum phosphide does not automatically render the waste P006 hazardous. P and U wastes are limited to commercial products or intermediates or off-specification versions thereof that are spilled, discarded, or intended to be discarded. Thus, a waste containing aluminum phosphide would be a P006 hazardous waste only if some or all of the aluminum phosphide in the waste were a commercial product, intermediate, or off-specifi- cation version thereof at some point in its existence prior to its incorporation into the waste. The available characterization data for the P and U wastes containing reactive listing constituents are presented in Table A-2 in Appendix A.

## 2.2 Industries Affected

The Agency does not intend to describe every industry that generates the P and U wastes containing reactive listing constituents, since any industrial facility that produces, uses, stores, and/or transports the chemicals has the potential of generating the waste. Table A-3, located in Appendix A, presents a description of the RCRA-permitted facilities that generated the above-listed wastes and the approximate volumes produced in 1986. Confidential Business Information (CBI) is not included. The following is a summary of the producers of the chemicals and the generators of the waste. Brief descriptions of the uses of the chemicals are also presented to indicate areas of potential waste generation.

P006 - Aluminum phosphide: There are no listed producers of this chemical in the SRI 1988 edition. One generator in EPA Region IV is listed in the 1986 TSDR Survey.
USE: Source of phosphine; in semiconductor research; as a fumigant.

P009 - Ammonium picrate: One producer located in EPA Region II is listed in SRI; however, the facility is selling all stock that was originally imported and does not manufacture ammonium picrate. No generators of P009 wastes were listed in the 1986 TSDR Survey.
USE: Explosives, fireworks, rocket propellants.

P015 - Beryllium dust: Two mines currently process beryllium ore. Thirteen generators are listed in the TSDR Survey as generating P015 in 1986: one in EPA Region II, two in EPA Region III, two in EPA Region IV, one in EPA Region V, one in EPA Region VI, one in EPA Region VIII, four in EPA Region IX, and one in EPA Region X.
USE: Source of neutrons when bombarded with alpha particles; as a neutron reflector and neutron moderator in nuclear reactors; in radio tube parts and aerospace structures; in inertial guidance systems.

P056 - Fluorine: One producer was listed in the SRI 1988 edition. One generator in Region II is listed in the 1986 TSDR Survey.
USE: Powerful fluorinating agent.

P068 - Methyl hydrazine: No producers are listed in SRI 1988 edition. Three generators are listed in the 1986 TSDR Survey: one in EPA Region III, one in EPA Region V, and one in EPA Region VI.
USE: In rocket fuel; intermediate in chemical synthesis.

P073 - Nickel carbonyl: One company located in EPA Region III is listed as a producer in the SRI 1988 edition. One generator in EPA Region III is listed in the 1986 TSDR Survey.
USE: Laboratory and organic synthesis.

P081 - Nitroglycerin: Five U.S. military installations are currently producing this chemical: two in EPA Region II, two in EPA Region III, and one in EPA Region VII. No P081 waste generators are listed in the 1986 TSDR Survey.
USE: Explosives (dynamite is 75 percent nitroglycerin) and veterinary pharmaceuticals.

P087 - Osmium tetroxide: Three producers are listed in the SRI 1988 edition: one in EPA Region I, one in EPA Region II, and one in EPA Region III. Eight generators of P087 are listed in the 1986 TSDR Survey: two Region II, one in Region IV, three in Region V, one in Region VI, and one in Region VIII.
USE: Oxidizing agent particularly for converting olefins to glycols. Catalyzes chlorate, peroxide, periodate, and other oxidations. As a fixing and staining agent for cell and tissue studies.

P096 - Phosphine: Eight producers are listed in the 1988 edition of SRI: one in Region I, one in Region II, one in Region IV, one in Region V, one in Region VI, and three in Region IX. Two facilities are listed as generators in the 1986 TSDR Survey: one in EPA Region V and one in EPA Region VI.
USE: Gaseous dopent for semiconductors.

P105 - Sodium azide: No producers are listed in the 1988 edition of SRI. Seventeen generators are listed in the 1986 TSDR Survey: one in EPA Region I, six in EPA Region II, three in EPA Region III, one in EPA Region IV, two in EPA Region V, three in EPA Region VI, and one in EPA Region X.
USE: In the preparation of hydrazoic acid, lead azide, pure sodium; as a propellant for inflating automotive safety bags; in weed and fruit rot control.

P112 - Tetranitromethane: One chemical producer in EPA Region II is listed in the SRI 1988 edition, and no generators of P112 are listed in the 1986 TSDR Survey.
USE: Oxidizer in rocket propellants. As explosive in admixture with toluene, to increase cetane number of diesel fuels. Reagent for detecting the presence of double bonds in organic compounds. Has been proposed as an irritant war gas.

P122 - Zinc phosphide: One chemical producer, located in EPA Region V, is listed in the SRI 1988 edition. One generator of P122 waste, located in EPA Region V, is listed in the 1986 TSDR Survey.
USE: In rat and field mouse poison preparations.

U023 - Benzotrichloride: In the 1988 edition of SRI, one company in Region II is listed as producing benzotrichloride, and the same company is listed as generating U023 in the 1986 TSDR Survey.
USE: Intermediate for pesticides.

U086 - 1,2-Diethylhydrazine: No producers are listed in the SRI 1988 edition. One generator of U086 in Region V is listed in the 1986 TSDR Survey.
USE: Polymer additives, fuels, photographic chemicals, and dyes.

U096 - a,a-Dimethylbenzylhydroperoxide: Four producers are listed in the SRI 1988 edition: two in Region II, one in Region III, and one in Region V. No generators are listed in the 1986 TSDR Survey.
USE: Intermediate in acetol/phenol production process.

U098 - 1,1-Dimethylhydrazine: One producer in Region VI is listed in the SRI 1988 edition. Three generators are listed in the 1986 TSDR Survey: one in Region II and two in Region V.
USE: Base for rocket fuel formulations.

U099 - 1,2-Dimethylhydrazine: No producers are listed in the SRI 1988 edition, and no generators are listed in the 1986 TSDR Survey.
USE: The base in rocket fuel formulations.

U103 - Dimethylsulfate: Two producers are listed in the SRI 1988 edition, and five generators are listed in the 1986 TSDR Survey. The two producers are located in EPA Regions II and III, and the five generators are located in Regions I, II, III, IV, and V.
USE: Methylating agent in the manufacture of many organic chemicals.

U109 - Diphenylhydrazine - No producers are listed in the SRI 1988 edition. Two generators are listed in the 1986 TSDR Survey, both located in EPA Region V.
USE: In the manufacture of hydrochloride, which is used as reagent for ababrnose and lactose.

U133 - Hydrazine - One producer, located in EPA Region V, is listed in the SRI 1988 edition, and 17 generators are listed in the 1986 TSDR Survey. Two of the generators are located in EPA Region I, one in Region II, one in Region III, three in Region IV, three in Region V, two in Region VI, two in Region VIII, one in Region IX, and two in Region X.
USE: Reducing agent; organic hydrazine derivative; rocket fuel.

U134 - Hydrogen fluoride: Four producers are listed in the SRI 1988 edition. According to the 1986 TSDR Survey, 16 facilities generate this waste: one in Region I, two in Region III, seven in Region V, one in Region VI, one in Region VIII, three in Region IX, and one in Region X.
USE: Catalyst in petroleum industry, use in fluorination processes, especially in the aluminum industry; in the manufacture of fluorides; in making fluorine-containing plastics; and for separating uranium isotopes.

U135 - Hydrogen sulfide: Twelve facilities are listed in the SRI 1988 edition as producing hydrogen sulfide, and five facilities are listed in the 1986 TSDR Survey as generating U135 wastes. The facilities producing hydrogen sulfide are located as follows: one in Region I, one in Region II, one in Region III, one in Region IV, two in Region V, three in Region VI, one in Region VIII, and two in Region IX. The facilities that generated hydrogen sulfide waste (U135) in 1986 are located as follows: one in Region I, one in Region III, one in Region IV, one in Region V, and one in Region IX.
USE: In the manufacture of chemicals; in metallurgy; as an analytical reagent.

U160 - Methyl ethyl ketone peroxide: No producers are listed in the SRI 1988 edition. Eight facilities are listed as generating U160 in the 1986 TSDR Survey: two in Region II, two in Region IV, one in Region V, one in Region VI, one in Region IX, and one in Region X.
USE: A widely used polymer-curing agent.

U189 - Phosphoric sulfide: Six facilities are listed as producers of phosphoric sulfide, and four facilities are listed as generators of U189 wastes. One facility producing phosphoric sulfide is located in EPA Region III, three in Region IV, one in Region V, and one in Region VII. The four facilities that generated U189 in 1986 are located in EPA Regions V, VI, VII, and X.
USE: In manufacture of lube oil additives and pesticides; manufacture of safety matches and ignition compounds; for introducing sulfur into organic compounds.

U249 - Zinc phosphide: One chemical producer, located in EPA Region V, is listed in the SRI 1988 edition. One generator of U249 waste, in EPA Region IX, is listed in the 1986 TSDR Survey.
USE: In rat and field mouse poison preparations.

## 2.3 Analytical Issues

For all but two P and U constituents (i.e., P015 - beryllium dust and U109 - diphenylhydrazine), methods to analyze the listed constituents in treatment residues are not currently available. Although the Agency recognizes that these compounds exist, and that the manufacturers may have methods to verify their purity and determine their product specifications, there are no EPA-approved analytical procedures to ascertain trace quantities of these chemicals either in the raw sample or in the residues from treatment. In addition, EPA has not identified any constituents in these wastes that could be used as a surrogate or as an indicator compound. These wastes include the following:

P006 - Aluminum phosphide
P009 - Ammonium picrate
P056 - Fluorine
P068 - Methyl hydrazine
P073 - Nickel carbonyl
P081 - Nitroglycerine
P087 - Osmium tetroxide
U023 - Benzotrichloride
U086 - 1,2-Diethylhydrazine
U096 - a,a-Dimethylbenzylhydroperoxide
U098 - 1,1-Dimethylhydrazine
U099 - 1,2-Dimethylhydrazine
U103 - Dimethyl sulfate
U133 - Hydrazine

P096 - Phosphine
P105 - Sodium azide
P112 - Tetranitromethane
P122 - Zinc phosphide (>10%)
U134 - Hydrogen fluoride
U135 - Hydrogen sulfide
U160 - Methyl ethyl ketone peroxide
U189 - Phosphoric sulfide
U249 - Zinc phosphide (<10%)

In the future, methods may be developed and approved for use in analyzing some of the P and U reactive constituents. Table A-4 in Appendix A presents the analytical problems associated with some of the reactive listing constituents for the P and U waste codes.

# 3. IDENTIFICATION OF APPLICABLE AND DEMONSTRATED TECHNOLOGIES

This section identifies the applicable and demonstrated treatment technologies for the P and U wastes containing reactive listing constituents. To be applicable, a technology must theoretically be usable to treat the waste in question or a similar waste. To be demonstrated, the technology must be employed in full-scale operation for the treatment of the waste in question or of a similar waste.

## 3.1 Applicable Treatment Technologies

Because the Agency has no waste characterization data specifically for the reactive P and U wastes, the applicable technologies are based on the characteristics described in Section 4.1 for the reactive listing constituents.

The following subsections present applicable treatment technologies for the (1) organic constituents, (2) metal constituents, and (3) inorganic constituents other than metals in nonwastewater and wastewater forms of the P and U wastes containing reactive constituents. For the purpose of the land disposal restrictions rule, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition are classified as nonwastewaters. For a more detailed discussion of each treatment technology, see the Treatment Technology Background Document (Reference 3).

(1) Applicable treatment technologies for organic constituents. For wastes containing reactive organic constituents, the technologies considered applicable are those that destroy the organics in a manner that is safe to human health and the environment.

**Nonwastewaters**. The technologies that the Agency has identified as applicable for treatment of nonwastewaters containing reactive organic constituents are incineration, fuel substitution, and chemical oxidation/ reduction.

Incineration is a technology that destroys the organic constituents in the waste by converting them to carbon dioxide, water, and other combustion products. Incineration may result in residuals that require treatment because of their metal content. Specifically, the residuals consist of ash and scrubber water. Incineration of highly explosive constituents may require treatment in units that are specially designed and fitted with certain explosion-proof equipment. These types of units are not typically found at commercial incineration facilities. The Agency is aware that these types of units are currently used for many of the Department of Defense explosive wastes. Fuel substitution, like incineration, destroys organic constituents in a waste. Since many of these wastes have high Btu values (e.g., hydrazine is used in rocket fuel), EPA believes that they are excellent candidates for fuel substitution. Additionally, the Agency has determined that these wastes can be chemically deactivated using chemical oxidation and chemical reduction technologies.

**Wastewaters**. The Agency has identified carbon adsorption followed by regeneration or incineration of the spent carbon, wet air oxidation, biological treatment, and solvent extraction as potentially applicable for treatment of hazardous P and U reactive organic constituents in wastewaters. Additionally, incineration has been identified for wastewaters containing high levels of reactive compounds that may become increasingly dangerous when concentrated on carbon or in an extraction fluid.

These applicable technologies destroy or reduce the total concentration of hazardous organic compounds in the waste (incineration, wet air oxidation, and biological treatment) or selectively remove

hazardous organic compounds from the waste stream (carbon adsorption and solvent extraction). The Agency believes that not all P and U wastes contain reactive listing constituents amenable to treatment with biological, wet air oxidation, and solvent extraction methods. However, most of these wastewaters are somewhat amenable to carbon adsorption because the constituents typically have low solubility in water, have high molecular weights, and have branched, rather than straight chain, molecular structures. Compounds with lower molecular weights and higher solubilities have also been successfully treated using carbon adsorption. Illustrations supporting this argument are presented in Appendix B.

(2) Applicable treatment technologies for metal constituents. The technologies considered applicable to treating P and U wastes containing reactive metal constituents are those that remove the reactive characteristic and/or recover the metals.

Nonwastewaters. For the metals present in nonwastewater P and U wastes, potentially applicable treatment technologies are stabilization and high-temperature metals recovery. Stabilization immobilizes the metal constituents to minimize leaching. High-temperature metals recovery provides for recovery of metals from wastes primarily by volatilization of some of the metals, subsequent condensation, and collection. The process yields a metal product for reuse and reduces the amount of waste that needs to be land disposed. Additionally, most metallic nonwastewaters can be slurried such that metals can be recovered or treated using wastewater treatment techniques.

Wastewaters. The technologies applicable for reactive constituents present in a wastewater matrix are chemical precipitation and removal of the precipitated metal solids using settling or sludge filtration. Chemical precipitation removes dissolved metals from solution, and settling/sludge filtration removes suspended solids.

(3) Applicable treatment technologies for inorganics other than metals. The technologies identified as potentially applicable are those that destroy the compound or render it less harmful by removing the reactive characteristic.

Nonwastewaters. EPA has identified incineration as applicable for nonwastewaters and gases with inorganic reactive constituents other than metals. Incineration is a technology that can destroy oxidizable inorganics. Gases can be vented directly into the incinerator. It should be mentioned that off-gases generated during the incineration of these wastes may require an afterburner and/or may need to be scrubbed before release to the atmosphere.

Gases that cannot be combusted should be solubilized in water. The resulting compound present in aqueous scrubber solution should be precipitated.

Wastewaters. The technologies identified as applicable for P and U wastewaters containing reactive listing constituents are chemical oxidation/reduction methods (e.g., alkaline chlorination) followed by precipitation.

## 3.2 Demonstrated Treatment Technologies

EPA considers demonstrated technologies to be those that are used on a full-scale basis to treat the waste of interest or a similar waste with regard to parameters that affect treatment selection. To determine what treatment technologies are "demonstrated" for the reactive P and U codes, the Agency contacted both generators and treaters of the wastes (see Reference 3). The following are summaries for each investigation concerning the demonstrated treatment technologies for the individual reactive P and U wastes.

P006 - Aluminum phosphide - EPA contacted the only generator listed in the 1986 TSDR Survey to gather information about treatment. This company is also the only known producer; however, the company claims that it no longer produces aluminum phosphide. The Agency believes zinc phosphide (P122) to be a similar waste based on physical and chemical characteristics. Incineration is demonstrated to treat P122. Consequently, the Agency believes incineration to be demonstrated to treat P006 nonwastewaters. Since this compound is water reactive, it is believed that wastewater forms cannot exist; however, phosphine, one of the products of decomposition, can be oxidized and precipitated with lime to form calcium phosphate.

P009 - Ammonium picrate - EPA could find no producers of this chemical listed in the SRI 1988 edition and no generators of the waste listed in the 1986 TSDR Survey. EPA believes that thermal destruction (i.e., incineration in specially designed units) is the best treatment for this waste. EPA believes that thermal destruction has been demonstrated to treat similar wastes; therefore, the Agency believes thermal destruction is demonstrated to treat P009 wastewaters and nonwastewaters. Additionally, carbon adsorption has been demonstrated for similar wastewaters containing explosive nitro groups (i.e., the listed waste K045 is spent carbon from treatment of wastewaters from the production of nitrate esters and other nitrated explosives). Consequently, the Agency believes carbon adsorption is demonstrated to treat P009 wastewaters.

P015 - Beryllium dust - The Agency has identified a metallic beryllium producer that accepts beryllium wastes including P015 for recycling. The wastes are manifested directly to the facility since it has a RCRA storage permit. The facility usually only accepts beryllium wastes that are not highly contaminated. The wastes generally go through several proprietary processes to remove some of the contaminants (such as iron and lead); the waste is then added to the production process to make metallic beryllium. Additionally, for highly contaminated wastes, the facility has a vacuum cleaning process to recover beryllium from the dust. Hence, EPA believes that recovery is demonstrated to treat P015.

P056 - Fluorine - Two companies (in Pennsylvania and New Jersey) use alkaline scrubbers to react with waste fluorine gas, although each uses a different alkaline agent. One company uses potassium hydroxide solution and then ships the spent solution to a commercial wastewater treatment plant for disposal. The other uses a caustic soda (sodium hydroxide) solution in its scrubber, and when

the resulting sodium fluoride concentration exceeds its solubility concentration (about 4.0 g/100 ml of water), the sodium fluoride is filtered out, drummed, and then shipped to a permitted disposer. Hence, solubilization in alkaline water is demonstrated to treat gaseous forms of P056. The Agency has also identified one facility using precipitation of fluoride as calcium fluoride (USEPA 1988f). Precipitation is demonstrated to treat P056 wastewaters.

P068 - Methyl hydrazine - EPA has found one commercial facility presently incinerating P068 nonwastewaters on a full-scale basis. Therefore, the Agency believes incineration to be demonstrated. The Agency has found one facility (NASA 1989) using an ozone/ultraviolet light oxidation treatment system for destruction of methyl hydrazines in a dilute aqueous solution (<100 ppm methyl hydrazine). The facility uses total organic carbon (TOC) and some intermediate products to monitor and evaluate the system; therefore, the Agency believes ozone/ultraviolet light to be demonstrated for the dilute wastewater forms of P068. However, the Agency believes that the oxidation process should be followed with carbon adsorption as a polishing step for removal because the oxidation treatment has been demonstrated only for dilute wastewaters. Carbon adsorption has been demonstrated on similar wastes. The Agency believes that these wastewaters can be easily adsorbed because of the branched nature of their structures, their high molecular weights, and their low solubility in water. Therefore, EPA believes carbon adsorption is demonstrated for P068 wastewaters. Following adsorption, the resulting nonwastewater carbon residual must be incinerated.

P073 - Nickel carbonyl - EPA contacted a nickel smelter that uses the Mond process to purify nickel (Bell 1989). During the Mond process, nickel carbonyl is passed through a heated bed of alumina at 200°C to recover nickel. The heat and alumina catalyst cause the nickel carbonyl to decompose into nickel and carbon dioxide. The carbon dioxide is fed to an incinerator and destroyed. EPA believes that for wastewater and nonwastewater forms of P073, nickel recovery using the Mond process is demonstrated. EPA has information indicating that chemical oxidation followed by stabilization is currently being sued for P073 wastes; therefore, this treatment is also demonstrated.

P081 - Nitroglycerin - The Agency has found one facility using thermal destruction for treatment of nonwastewater forms of a nitroglycerin waste. EPA has determined that one facility is using rotary kiln incineration for treatment of nitroglycerin wastewaters and nonwastewater slurries. EPA believes that thermal destruction and incineration are demonstrated for nonwastewaters and that incineration is demonstrated for wastewaters. Additionally, carbon adsorption has been demonstrated for similar

wastewaters containing explosive nitro groups (i.e., the listed waste K045 is spent carbon for treatment of wastewaters from the production of nitrate esters and other nitrated explosives). Consequently, the Agency believes that carbon adsorption, as well as incineration, is demonstrated to treat P081 wastewaters.

P087 - Osmium tetroxide - EPA has found one facility that bench treated an aqueous solution of osmium tetroxide with potassium iodide to precipitate the osmium metal. The metal was recovered and sent to a producer of osmium chemicals. (Since osmium is presently valued at $1,350 per ounce, it is unlikely that anyone is discarding the material.) According to the 1986 Minerals Yearbook, only 2 pounds of osmium tetroxide were produced; therefore, the Agency believes it appropriate to use bench-scale performance data. Hence, recovery is a demonstrated technology for wastewater forms. Similar nonwastewaters have been slurried and treated as stated above; therefore, the Agency believes precipitation followed by recovery of the osmium to be demonstrated for nonwastewater forms of P087.

P096 - Phosphine - The Agency believes that it is common practice to incinerate phosphine to phosphorus pentoxide and scrub the off-gas with lime solution to generate calcium phosphate. This scrubber water can be treated with neutralization. Hence, the Agency considers incineration to be demonstrated to treat phosphine gas and chemical oxidation followed by precipitation to be demonstrated to treat P096 wastewaters.

P105 - Sodium azide - EPA has found one facility using incineration for treatment of P105 nonwastewaters; therefore, the Agency has concluded that incineration is demonstrated for nonwastewaters. Nitrite treatment can be accomplished by adding sodium nitrite to sodium azide to produce nitrogen and sodium hydroxide. This treatment is currently used by a facility for treatment of lead azide. Lead azide is believed to be a similar waste based on chemical properties; consequently, the Agency considers chemical oxidation to be demonstrated to treat P105 wastewaters.

P112 - Tetranitromethane - EPA has found one commercial facility incinerating dilute concentrations of P112. This facility claims that the waste is sufficiently stable when blended with other wastes to form a dilute mixture that can be incinerated. Hence, incineration is demonstrated to treat P112 wastewaters and nonwastewaters. Additionally, carbon adsorption has been demonstrated for similar wastewaters containing explosive nitro groups (i.e., the listed waste K045 is spent carbon for treatment of wastewaters from the production of nitrate esters and other nitrated explosives). Consequently, the Agency considers carbon adsorption to be demonstrated to treat P112 wastewaters.

P122 - Zinc phosphide (>10%) - EPA has found one commercial facility using incineration for treatment of P122 nonwastewaters and consequently believes that incineration is demonstrated. Since this compound reacts with water, it is believed that wastewater forms cannot exist; however, the dissociated zinc can be precipitated with lime.

U023 - Benzotrichloride - EPA has found one commercial facility using incineration for treatment of U023 nonwastewaters and consequently believes that incineration is demonstrated. Since this compound reacts with water, it is believed that wastewater forms cannot exist; however, carbon absorption has been demonstrated to treat benzoic acid, which is one of the products formed by the reaction of benzotrichloride with water.

U086 - N,N-Diethylhydrazine - EPA has found one commercial facility using incineration for treatment of U086 nonwastewaters and consequently believes that incineration is demonstrated. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that U086 wastewaters can be easily adsorbed because of the branched nature of their structures, high molecular weights, and low solubility in water. Therefore, the Agency believes carbon adsorption to be demonstrated for these wastewaters.

U096 - a,a-Dimethylbenzylhydroperoxide - EPA has found one commercial facility using incineration for treatment of U096 nonwastewaters; hence, incineration is demonstrated. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that these wastewaters can be easily adsorbed because of the branched nature of their structures, their high molecular weights, and their low solubility in water. Therefore, the Agency considers carbon adsorption to be demonstrated for these wastewaters.

U098 - 1,1-Dimethylhydrazine - EPA has found one commercial facility using incineration for treatment of U098 nonwastewaters; therefore, incineration is demonstrated. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that these wastewaters can be easily adsorbed because of their polar nature. Therefore, the Agency considers carbon adsorption to be demonstrated for these wastewaters.

U099 - 1,2-Dimethylhydrazine - EPA has found one commercial facility using incineration for treatment of U099 nonwastewaters; therefore, incineration is demonstrated. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that these wastewaters can be easily adsorbed because of the branched nature of their structures, their high molecular weights, and their low solubility in water. Therefore, the Agency considers carbon adsorption to be demonstrated for these wastewaters.

U103 - Dimethyl sulfate - EPA has found one commercial facility using incineration for treatment of U103 nonwastewaters; therefore, incineration is demonstrated. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that these wastewaters can be easily adsorbed because of the branched nature of their structures, their high molecular weights, and their low solubility in water. Therefore, the Agency considers carbon adsorption to be demonstrated for these wastewaters.

U109 - 1,2-Diphenylhydrazine - EPA has found one commercial facility using incineration for treatment of U109 nonwastewaters; therefore, incineration is demonstrated. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that these wastewaters can be easily adsorbed because of their polar nature. Therefore, the Agency considers carbon adsorption to be demonstrated for these wastewaters.

U133 - Hydrazine - EPA has found one commercial facility using incineration for treatment of U133 nonwastewaters; therefore, incineration is demonstrated. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that these wastewaters can be easily adsorbed because of their polar nature. Therefore, the Agency considers carbon adsorption to be demonstrated for these wastewaters.

U134 - Hydrogen fluoride - The disposal of hydrogen fluoride is similar to the disposal of fluorine. In fact, the same scrubbing equipment and the same alkaline scrubbing solutions are used by two facilities for both waste fluorine and waste hydrogen fluoride. Two other facilities utilize scrubbing, or a variation of scrubbing, for their waste hydrogen fluoride gas but do not scrub fluorine. A fifth vendor uses recovery and recycle techniques on its gas cylinders, but its situation is special because its locations deal only in 850-pound, 1-ton, and 20-ton containers. With such large containers, recovery and recycle are the most technically feasible practice. Because four companies use alkaline scrubbing and one uses product recovery and recycle, these are demonstrated technologies.

U135 - Hydrogen sulfide - It is common practice to incinerate hydrogen sulfide, which will generate sulfur dioxide off-gas. The off-gas can be scrubbed with alkaline solution to generate calcium sulfate. Hence, the Agency believes that incineration is demonstrated to treat hydrogen sulfide gas and that chemical oxidation of any sulfide to sulfate, followed by precipitation, is demonstrated to treat U135 wastewaters.

U160 - Methyl ethyl ketone peroxide - One facility reportedly uses thermal destruction to treat U160 nonwastewaters. EPA has also found one commercial facility using incineration for treatment of U160 nonwastewaters; therefore, both technologies are demonstrated to treat U160 nonwastewaters. Carbon adsorption has been demonstrated on similar wastewaters. The Agency believes that these wastewaters can be easily adsorbed because of their polar nature. Therefore, the Agency considers carbon adsorption to be demonstrated for these wastewaters.

U189 - Phosphorus sulfide - EPA has found one commercial facility using incineration for treatment of U189 nonwastewaters; hence, incineration is demonstrated. This compound reacts with water, and consequently it is believed that wastewater forms cannot exist.

U249 - Zinc phosphide (<10%) - EPA has found one commercial facility using incineration for treatment of U249 nonwastewaters; hence, incineration is demonstrated. Since this constituent is water reactive, it is believed that wastewater forms cannot exist; however, the dissociated zinc can be precipitated with lime.

# 4. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section presents the rationale for determination of best demonstrated available technology (BDAT) for each reactive P and U waste. First, the Agency examines all the demonstrated technologies to determine whether one of the technologies performs significantly better than another. Next, the "best" performing treatment technology is evaluated to determine whether the resulting treatment is "substantial." Since EPA does not have performance data for any of these wastes and because of the lack of analytical methods, the Agency's evaluation of "substantial" is based on the performance of technologies established in the Agency's BDAT data base. If the "best" technology provides "substantial" treatment and it has been determined that the technology is also commercially available to the affected industry, then the technology represents BDAT.

For the purpose of BDAT determinations, the Agency has identified four subgroups according to similarities in treatment, chemical composition, and structure. These groups are Incinerable Reactive Organics and Hydrazine Derivatives, Incinerable Inorganics, Fluorine Compounds, and Recoverable Metallics. The discussion of the treatment standards applicable to each subgroup follows. Table 4-1 at the end of this section summarizes the treatment standards for P and U wastes containing reactive listing constituents.

## 4.1 BDAT for Incinerable Reactive Organics and Hydrazine Derivatives

The following constituents have been grouped together because they are organic constituents that can be incinerated:

P009 - Ammonium picrate
P081 - Nitroglycerine
P112 - Tetranitromethane
P068 - Methyl hydrazine
P105 - Sodium azide
U086 - 1,2-Diethylhydrazine

U023 - Benzotrichloride
U096 - a,a-Dimethylbenzylhydroperoxide
U103 - Dimethyl sulfate
U160 - Methyl ethyl ketone peroxide
U098 - 1,1-Dimethylhydrazine
U099 - 1,2-Dimethylhydrazine
U109 - 1,2-Diphenylhydrazine
U133 - Hydrazine

The Agency does not believe that concentration-based treatment standards can be established for these wastes at this time. The major problems in establishing concentration-based standards for these wastes are (1) EPA does not currently have an analytical method for measuring many of these wastes in treatment residues and (2) where the Agency does have methods, there are no data available on the treatment of these chemicals. In cases when there is no verified analytical method for a particular waste, EPA tries to find an appropriate measurable surrogate or indicator compound. However, no constituent has been identified in these wastes that could be used as a surrogate or indicator compound.

One of the specific problems encountered in analysis of P068, P105, P112, U023, U098, U099, and U103 is that these wastes break down quickly in water (hydrolyze) and the analysis of wastewater forms of these wastes is very difficult, as well as often hazardous, because of the intensity of the reaction. In addition, the Agency lacks data on what effects the hydrolysis products would have on the environment. Also, verified analytical methods do not currently exist for the quantification of these hydrolysis products in treatment residues.

Another analytical problem is created because P081 wastes are only quantifiable by High Performance Liquid Chromatography (HPLC) methods. Although HPLC techniques have been used to quantify certain chemicals in relatively clean aqueous matrices, the Agency has not completely verified that HPLC is appropriate for analysis of either untreated wastes or treatment residuals. There is only one HPLC method currently listed in SW-846 as applicable for analysis of solid wastes, with very limited applicability. However, the Agency is in the process of validating other HPLC methods, including multiple-column HPLC systems and HPLC units

coupled with mass spectroscopy. Until this method validation work is completed, the Agency does not believe that it should establish concentration-based treatment standards for these particular U and P chemicals. Further, the Agency currently lacks data on treatment of hazardous wastes based on HPLC analyses. In addition, there are no verified SW-846 analytical methods for measuring P009 and U133 in treatment residues.

Nonwastewaters. The Agency has identified incineration, fuel substitution, and chemical oxidation/reduction as demonstrated technologies for treatment of reactive organic constituents. These technologies are considered commercially available and provided substantial treatment of reactive organic constituents; therefore, they are considered "best."

Many of the U and P wastes exist as concentrated off-specification chemicals. Depending on other constituents present in the waste matrix, these off-specification chemicals could potentially be dissolved in a suitable waste solvent prior to treatment (i.e., incinerated in a liquid injection system). There is, however, risk associated with dissolving these highly reactive chemicals; therefore, treatment without dissolving may be preferable. EPA is not precluding the dissolution of these chemicals to facilitate treatment. In cases where there is a significant volume of these chemicals, dissolution may be necessary to reduce air emissions or to reduce the risk of explosion prior to treatment.

Since the analytical problems previously described preclude setting concentration-based treatment standards and RCRA section 3004(m) allows the Agency to establish either levels or methods of treatment, the Agency is promulgating a treatment standard of "Incineration (INCIN), Fuel Substitution (FSUBS), Chemical Oxidation (CHOXD), or Chemical Reduction (CHRED) as Methods of Treatment" for the nonwastewater forms of these U and P wastes. See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five-letter technology code in parentheses.

Although there is an SW-846 method for U109, the Agency is not promulgating a numerical standard for this waste since it is very similar to P068, U086, U098, U099, and U133 (all are hydrazine compounds). Further, there are no performance data from which to establish numerical standards, and it is the Agency's belief that the thermal and chemical destruction technologies specified will provide effective treatment for this waste.

**Wastewaters**. The Agency determined that carbon adsorption was demonstrated, available, and provided substantial treatment; it was therefore considered "best." Additionally, for wastewaters containing high concentrations of constituents, incineration was determined to be demonstrated, available, and therefore "best."

Data reviewed by the Agency indicate that some of these wastes (i.e., P068) can be effectively treated by ozone/ultraviolet light oxidation (chemical oxidation). EPA also has information indicating that biodegradation is capable of destroying the reactive organic constituents in the wastewater forms of these P and U wastes. These technologies are demonstrated, available, and provide substantial treatment; they are therefore considered "best" for some wastes in this group.

Based on the information described above, the Agency is promulgating a treatment standard of "Incineration (INCIN), Chemical Oxidation (CHOXD), Chemical Reduction (CHRED) or Carbon Adsorption (CARBN), or Biodegradation (BIODG) as Methods of Treatment" for the wastewater forms of these P and U wastes. See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five-letter technology code in parentheses.

The Agency is unaware of any alternative treatment or recycling technologies that have been examined specifically for these U and P wastes. The Agency solicited data and comments on such technologies but

received no response on this issue. In any case, the treatment standards for the nonwastewater and wastewater forms of these P and U wastes do not preclude recycling (provided the recycling is not a use constituting disposal).

## 4.2 BDAT for Incinerable Inorganics

The following constituents have been grouped together because they consist of compounds containing sulfur, nitrogen, and phosphorus:

P006 - Aluminum phosphide
P096 - Phosphine
P122 - Zinc phosphide (>10%)
U135 - Hydrogen sulfide
U189 - Phosphorus sulfide
U249 - Zinc phosphide (<10%)

The Agency does not believe that numerical treatment standards can be established for these wastes at this time. The major problem in establishing concentration-based standards for these wastes is that EPA does not currently have an analytical method for measuring these wastes in treatment residues. In cases when there is no analytical method for a particular waste, EPA tries to find an appropriate measurable surrogate or indicator compound; however, no constituent has been identified in these wastes that could be used as a surrogate or indicator compound.

One of the specific problems encountered in analysis of P006 is that this waste breaks down quickly in water (hydrolyzes), making the analysis of wastewater forms of this waste very difficult. In addition, an SW-846 analytical method does not exist for U189.

Nonwastewaters. The Agency has information indicating that incineration and chemical oxidation/reduction can be used for effective treatment for phosphine gas (P096) and hydrogen sulfide gas (U135). The information indicates that both of these gases can be treated by controlled reaction with an aqueous solution of potassium permanganate.

This treatment allows the margin of safety that venting into an incinerator does not, since both gases, when heated, emit highly toxic oxides of either sulfur or phosphorus.

The Agency still believes that incineration can be used to effectively and safely treat some of these wastes. However, because many of these wastes will contain high concentrations of sulfur and phosphorus when discarded as off-spec products, they will require as part of their treatment the use of air pollution control equipment capable of controlling the emissions of phosphorus and sulfur to acceptable levels.

The Agency believes that both incineration and chemical oxidation/reduction have been proven to provide substantial treatment. These technologies are also commercially available; hence they are "best."

Based on available information, the Agency is promulgating a treatment standard of "Incineration (INCIN), Chemical Oxidation (CHOXD), or Chemical Reduction (CHRED) as Methods of Treatment" for P006, P096, P122, U135, U189, and U249 nonwastewaters. See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five-letter technology code in parentheses.

**Wastewaters**. The Agency reviewed information indicating that these wastewaters can be effectively treated by incineration or chemical oxidation/reduction. The Agency believes that both incineration and chemical oxidation/reduction provide substantial treatment and are also commercially available; hence, they are "best."

Based on available information, the Agency is promulgating a treatment standard of "Incineration (INCIN), Chemical Oxidation (CHOXD), or Chemical Reduction (CHRED) as Methods of Treatment" for the wastewater forms of P006, P096, P122, U135, U189, and U249 wastewaters. See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five-letter technology code in parentheses.

The Agency is currently unaware of any alternative treatment or recycling technologies that have been examined specifically for the nonwastewater or wastewater forms of these P and U wastes. The Agency solicited data and comments on this, but received no response on this issue. The final rule, in any case, does not preclude recycling (provided the recycling does not involve burning as fuel or is not a use constituting disposal; see 40 CFR 261.33).

## 4.3 BDAT for Fluorine Compounds

The following constituents were grouped together because of their physical form and because they contain fluorine:

P056 - Fluorine
U134 - Hydrofluoric Acid

Nonwastewaters. Both of these wastes can exist as gases and gases solubilized in wastewaters (although U134 is often generated as an aqueous acid). In the gaseous form, alkaline scrubbing to achieve neutralization has been demonstrated to treat P056 and U134, although recycling and recovery can be used when applicable for some containerized gases.

EPA is promulgating "Adsorption (ADGAS) Followed by Neutralization (NEUTR) as a Method of Treatment" for P056 nonwastewaters and "Neutralization (NEUTR) or Adsorption (ADGAS) Followed by Neutralization (NEUTR) as Methods of Treatment" for U134 nonwastewaters since this waste can exist as an acidic solution or a gas. See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five letter technology code in parentheses. The Agency made this decision as a result of information indicating that most facilities are currently treating gaseous forms of P056 and U134 by reacting the gases with alkaline solution and that it is common practice to neutralize waste hydrofluoric acid (U134).

The Agency has information indicating that these fluorine compounds are mixed with other wastes requiring incineration and that they can be safely incinerated. The Agency is not precluding incineration as long as the acid off-gases are scrubbed with alkaline reagents to achieve the appropriate treatment standard. In this case, the water will act as the adsorbent and the alkaline reagents will neutralize the acidity.

**Wastewaters**. The Agency has reviewed data applicable for the wastewater forms of P056 and U134 wastes. These data were used to develop numerical treatment standards for BDAT list constituents, such as fluoride. Detailed information on the development of these treatment standards is included in the Best Demonstrated Available Technology (BDAT) Background Document for Wastewaters Containing BDAT List Constituents (Reference 4). A summary of the information used to develop the fluoride treatment standard is included in Appendix C.

Based on the information described above, the Agency is promulgating a concentration-based wastewater treatment standard of 35 mg/l for fluoride in P056 and U134 wastewaters.

## 4.4 BDAT for Recoverable Metallics

All the wastes in this group contain metallic elements (i.e., beryllium, osmium, and nickel) that can be recovered because of their high economic value. Information available to the Agency indicates that recovery of these metallic elements from these wastes is feasible and is currently practiced.

P015 - Beryllium dust
P073 - Nickel carbonyl
P087 - Osmium tetroxide

Nonwastewaters. The Agency identified recovery and oxidation followed by stabilization as demonstrated technologies for P073 wastes. The Agency reviewed information indicating that it is inappropriate to establish recovery as the only acceptable treatment method for nickel carbonyl (P073). Because of the highly reactive nature of the chemical and the fact that it is generated in small quantities, long-term storage to obtain quantities sufficient to justify recovery either onsite or offsite would present a significant safety hazard. The information indicates that P073 can be treated by oxidation, either thermally in an incinerator or chemically in a laboratory-scale treatment facility, followed by stabilization. This is the only safe, economical, and environmentally sound treatment method for small quantities of nickel carbonyl.

Based on this information, the Agency believes that it is not always practical to recover small quantities of nickel and that oxidation of wastewaters followed by stabilization of nonwastewaters will provide effective treatment for P073 wastes. Since EPA has performance data on the stabilization of nickel in nonwastewaters believed to be similar to P073, the Agency has decided to develop a concentration-based standard. The performance data used were from the stabilization of F006 nonwastewaters. These F006 wastes contained high concentrations of nickel (as high as 170,000 ppm). Therefore, the Agency believes that these data are applicable to P073 nonwastewaters. Based on these data, the Agency is promulgating a concentration-based standard of 0.32 mg/l nickel for P073 nonwastewaters. For a detailed discussion on the development of this treatment standard, see the BDAT background document for F006 (Reference 5). A summary of the stabilization performance data used is presented in Appendix D.

For P015 and P087, recovery was the only demonstrated technology identified. The Agency reviewed information from a producer of beryllium and beryllium-containing products indicating that although only very

small quantities of P015 are generated at any one time, recovery is a viable and preferred treatment method in light of the high economic value of the recovered beryllium. Additionally, the Agency is aware that it is current practice to recover osmium from P087 using bench-scale technologies because of the high economic value of the recovered osmium. Consequently, the Agency is promulgating a treatment standard of "Recovery (REMETL or RTHRM) as a Method of Treatment" for P015 and P087 nonwastewaters. See 40 CFR 268.42, Table 1, for a detailed description of the technologies referred to by the five-letter technology codes in parentheses.

**Wastewaters**. The Agency identified recovery and chemical oxidation as the only demonstrated treatment of wastewaters containing P015, P073, and P087 wastes. These technologies are commercially available and were therefore considered "best."

Based on the information received for P073 wastes (as previously described in the nonwastewater section), the Agency has decided to develop a concentration-based standard for P073 wastewaters. This standard is based on the chemical oxidation of K062 wastewaters. The wastewaters treated contained between 4 and 100,310 ppm of nickel. Therefore, the Agency believes that these data are applicable to P073 wastewaters. Based on these data, the Agency is promulgating a concentration-based standard of 0.44 mg/l nickel for P073 wastewaters. For a detailed discussion on the development of this treatment standard, see the BDAT background document for K062 (Reference 6). A summary of the chemical oxidation performance data used is presented in Appendix E.

Based on the information reviewed for P015 and P087 wastes (as previously described in the nonwastewater section), the Agency is promulgating a treatment standard of "Recovery (RMETL or RTMRM) as a

Method of Treatment" for P015 and P087 wastewaters. See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five-letter technology code in parentheses.

TABLE 4-1 BDAT TREATMENT STANDARDS FOR P AND U WASTES CONTAINING REACTIVE LISTING CONSTITUENTS

| BDAT TREATMENT STANDARDS FOR P009, P068, P081, P105, P112, U023, U086, U096, U098, U099, U103, U109, U133, AND U160 [Nonwastewaters] |
|---|
| INCINERATION (INCIN) FUEL SUBSTITUTION (FSUBS), CHEMICAL OXIDATION (CHOXD), OR CHEMICAL REDUCTION (CHRED) AS METHODS OF TREATMENT* |
| BDAT TREATMENT STANDARDS FOR P009, P068, P081, P112, U023, U086, U096, U098, U099, U103, U109, U133, AND U160 [Wastewaters] |
| INCINERATION (INCIN), CHEMICAL OXIDATION (CHOXD), CHEMICAL REDUCTION (CHRED), CARBON ADSORPTION (CARBN), OR BIODEGRADATION (BIODG) AS METHODS OF TREATMENT* |
| BDAT TREATMENT STANDARDS FOR P006, P096, P122, U135, and U249 [Nonwastewaters and Wastewaters] |
| INCINERATION (INCIN), CHEMICAL OXIDATION (CHOXD), OR CHEMICAL REDUCTION (CHRED) AS METHODS OF TREATMENT* |

* Incinerators must comply with 40 CFR 264 Subpart O or 265 Subpart O. Fuel substitution units must comply with 40 CFR Part 266 Subpart D. See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five-letter technology code in parentheses.

Table 4-1 (continued)

BDAT TREATMENT STANDARDS FOR P056
[Nonwastewaters]

ADSORPTION (ADGAS) FOLLOWED BY NEUTRALIZATION (NEUTR)
AS A METHOD OF TREATMENT*

BDAT TREATMENT STANDARDS FOR U134
[Nonwastewaters]

NEUTRALIZATION (NEUTR) OR ADSORPTION (ADGAS) FOLLOWED
BY NEUTRALIZATION (NEUTR)
AS METHODS OF TREATMENT*

BDAT TREATMENT STANDARDS FOR
P056 AND U134
[Wastewaters]

| Regulated Constituent | Maximum for any Single Grab Sample Total Composition (mg/l) |
|---|---|
| FLUORIDE | 35 |

BDAT TREATMENT STANDARDS FOR
P015 AND P087
[Nonwastewaters and Wastewaters]

RECOVERY (RMETL OR RTHRM) AS A METHOD OF TREATMENT*

* See 40 CFR 268.42, Table 1, for a description of the technologies referred to by a five-letter technology code in parentheses.

Table 4-1 (continued)

BDAT TREATMENT STANDARDS FOR P073
[Nonwastewaters]

| Regulated Constituent | Maximum for any Single Grab Sample Total Composition (mg/kg) |
|---|---|
| NICKEL | 0.32 |

BDAT STANDARDS FOR P073
[Wastewater]

| Regulated Constituent | Maximum for any Single Grab Sample Total Composition (mg/l) |
|---|---|
| NICKEL | 0.44 |

# 5. ACKNOWLEDGMENTS

This document was prepared for the U.S. Environmental Protection Agency, Office of Solid Waste, by Versar Inc. under Contract No. 68-W9-0068. Mr. Larry Rosengrant, Chief, Treatment Technology Section, Waste Treatment Branch, served as the EPA Program Manager during the preparation of this document and the development of treatment standards for the P and U wastes containing reactive listing constituents. The technical project officer for the waste was Ms. Laura Fargo. Mr. Steven Silverman served as legal advisor.

Versar personnel involved in the preparation of this document included Mr. Jerome Strauss, Program Manager; Mr. Stephen Schwartz, Assistant Program Manager; Mr. James Berkes, Principal Investigator and Author; Ms. Justine Alchowiak, Quality Assurance Officer; Ms. Juliet Crumrine and Ms. Martha Martin, Technical Editors; and Ms. Sally Gravely, Program Secretary.

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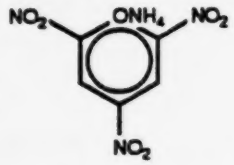
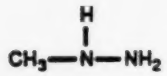
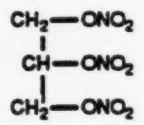
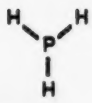
# APPENDIX A

## WASTE CHARACTERIZATION, INDUSTRIAL DESCRIPTIONS, AND ANALYTICAL PROBLEMS ASSOCIATED WITH WASTES CONTAINING P AND U REACTIVE LISTING CONSTITUENTS

## TABLE A-1 CHEMICAL STRUCTURES FOR REACTIVE P AND U LISTING CONSTITUENTS

| *Waste code* | *Chemical constituent* | *Structure* | *Molecular weight* |
|---|---|---|---|
| P006 | Aluminum phosphide | Al—P | 58.0 |
| P009 | Ammonium picrate |  | 246.1 |
| P015 | Beryllium dust | Be | 9.0 |
| P056 | Fluorine | $F_2$ | 38.0 |
| P068 | Methyl hydrazine |  | 46.1 |
| P073 | Nickel carbonyl | | 170.7 |
| P081 | Nitroglycerin |  | 227.1 |
| P087 | Osmium tetroxide | $OsO_4$ | 254.2 |
| P096 | Phosphine |  | 34.0 |
| P105 | Sodium azide | Na—N—N≡N | 65.0 |

## TABLE A-1 (CONTINUED)

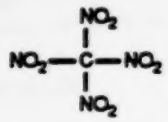
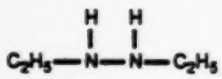
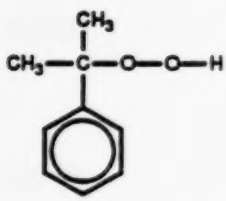
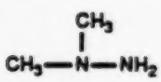
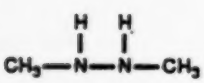
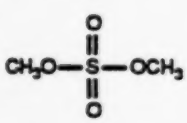
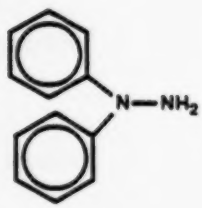
| Waste code | Chemical constituent | Structure | Molecular weight |
|---|---|---|---|
| P112 | Tetranitromethane |  | 196.0 |
| P122/U249 | Zinc Phosphide | $Zn_3P_2$ | 258.1 |
| U023 | Benzotrichloride | | 195.5 |
| U086 | 1,2-Diethylhydrazine |  | 88.2 |
| U096 | a,a-Dimethylbenzyl-hydroperoxide |  | 152.1 |
| U098 | 1,1-Dimethylhydrazine |  | 60.1 |
| U099 | 1,2-Dimethylhydrazine |  | 60.1 |
| U103 | Dimethyl Sulfate |  | 126.1 |
| U109 | Diphenylhydrazine |  | 184.2 |

TABLE A-1 **(CONTINUED)**

| *Waste code* | *Chemical constituent* | *Structure* | *Molecular weight* |
|---|---|---|---|
| U133 | Hydrazine | $H_2N—NH_2$ | 32.1 |
| U134 | Hydrogen Fluoride | H—F | 20.1 |
| U135 | Hydrogen Sulfide | H—S | 34.1 |
| U160 | Methyl Ethyl Ketone Peroxide | $CH_3CH_2—C(—O—O—CH_3)$ | 88.0 |
| U189 | Phosphorus Sulfide | $P_2S_5$ | 222.3 |

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Table A-2 P and U Wastes Containing Reactive Listing Constituents

| WASTE CODE | WASTE DESCRIPTION | SOURCE OF WASTE GENERATION | QUANTITY | PERCENT SOLIDS | PERCENT WATER | CONSTITUENTS PRESENT IN PERCENTAGE LEVELS |
|---|---|---|---|---|---|---|
| P008(MIXED) | Caustic solution with metals&cyanides | Wastewater treatment | 20 T | P | P | Cd(1-10%),As & cmpds,NOS(1-10%), Cyanides,NOS(1-10%) |
| P009(MIXED) | Mixed lab packs/empty containers | Laboratory wastes/cleanup of spill residues | 16 T | DK | DK | N |
| P016 | Metal scale,filings or scrap | Size reduction | 1 T | ND | ND | N |
| P016 | Other "dry" ash,slag or thermal residue/metal scale, or scrap | Other waste production process/combustion processes | 24 G | 99 | 0 | Beryllium & cmpds,NOS(10-25%) |
| P016 | Metal scale,filings or scrap | Other process | 120 G | 99 | NA | Be(75-90%),Cu(1-10%),Ni(1-10%),Zn(1-10%) |
| P016 | Other metal salts/chemicals | Laboratory wastes/discarding of off-spec material | 0 | 99 | 0 | Be(>90%) |
| P016(MIXED) | Metal scale,filings or scrap | Physical scraping/removing | 3 T | 99 | 1 | Be(1-10%) |
| P016(MIXED) | Soil contaminated with organics only/reactive cyanide chemicals | Discarding of out-of-date products or chemicals | 2 T | 99 | DK | N |
| P016(MIXED) | Mixed lab packs | Other process | 8000 G | 20 | 20 | N |
| P016(MIXED) | Metal scale,filings or scrap | Size reduction | 217 G | 96 | DK | Be(1-10%),Pb(1-10%),Cyanides(0.1-1%) |
| P066 | Inorganic gases | Discarding of out-of-date products or chemicals | 1 T | 0 | 0 | Fluorine(>90%) |
| P066(MIXED) | Other untreated waste | Surface coating | 42 G | 10 | 50 | Cd(10-25%),Cr(10-25%),Cr+6(1-10%),Fluorine(500ppm-0.1%) |
| P088 | Other inorganic liquid | Discarding of off-spec material | 1000 T | 0 | 99 | Methyl hydrazine(1-10%) |
| P088 | Other inorganic liquid | Physical scraping or removing/flush rinsing | 120 G | DK | DK | Hydrazine(1-10%) |
| P088(MIXED) | Lab packs of old chemicals only | Laboratory wastes | 1 T | NA | NA | N |
| P088(MIXED) | Other inorganic liquid | Laboratory wastes | 100 G | 0 | 95 | 1,2-Dimethyl hydrazine(1-10%),Methyl hydrazine(1-10%),Hydrazine(1-10%) |
| P088(MIXED) | Lab packs of debris only | Other waste production process | 6 T | 99 | DK | Hydrazine(0.1-1%),Methyl hydrazine(01.-1%) |
| P087 | Concentrated off-spec or discarded product | Discarding of out-of-date products or chemicals | ND | DK | DK | Osmium tetroxide(>90%) |
| P087 | Other metal salts/chemicals | Discarding of out-of-date products or chemicals | ND | 99 | NA | Osmium tetroxide(>90%) |
| P087 | Other metal salts/chemicals | Laboratory wastes/ discarding of out-of-date chemicals | 1 G | 99 | 0 | Osmium tetroxide(>90%) |
| P087 | Concentrated off-spec or discarded product | Laboratory wastes/ discarding of out-of-date chemicals | 1 T | DK | DK | Osmium tetroxide(500PPM-0.1%) |
| P087(MIXED) | Mixed lab packs | Laboratory wastes | 56 G | 96 | 4 | Osmium tetroxide(0.1-1%),Phenol(0.1-1%),Aniline(0.1-1%) |
| P087(MIXED) | Mixed lab packs | Laboratory wastes/ discarding of out-of-date chemicals | 1 T | P | P | N |
| P017(MIXED) | Lab packs of old chemicals only | Laboratory wastes | 1 T | P | P | N |
| P105 | Concentrated off-spec or discarded product | Discarding of out-of-date products or chemicals | 1 T | DK | DK | N |
| P105 | Other metal salts/chemicals | Discarding of out-of-date products or chemicals | 1 T | NA | DK | N |
| P105 | Other waste inorganic chemicals | Discarding of out-of-date products or chemicals | 1 T | 99 | 0 | N |
| P105 | Other reactive salts/chemicals | Laboratory wastes/ discarding of out-of-date chemicals | 1 T | 99 | 0 | N |
| P105 | Concentrated off-spec or discarded product | Laboratory wastes/ discarding of out-of-date chemicals | 1 T | DK | 99 | N |
| P105(MIXED) | Caustic sol'n w/metals&cyanides | Laboratory wastes | 110 G | DK | DK | N |
| P105 (MIXED) | Aqueous waste w/low other toxic organics | Distillation and fractionation | 1416000 T | 0 | 80 | N |
| P105 (MIXED) | Sediment or lagoon dragout contaminated with organics | Decantation/sedimentation | 104 T | 40 | 60 | N |
| P105(MIXED) | Concentrated off-spec or discarded product | Discarding of out-of-date products or chemicals | ND | 99 | DK | N |
| P105(MIXED) | Other waste inorganic chemicals | Discarding of out-of-date products or chemicals | 1 T | NA | NA | N |
| P122 | Concentrated off-spec or discarded product | Discarding of out-of-date products or chemicals | 1 T | DK | DK | Zn(10-25%), Zinc phosphide(10-25%) |
| P122 | Other reactive salts/chemicals | Discarding of out-of-date products or chemicals | 1 T | 100 | ND | Zinc phosphide(75-90%), |
| P122 | Inorganic gases | Laboratory wastes/ discarding of out-of-date chemicals | 1 G | 99 | 0 | Zn(75-90%), Zinc phosphide(>90%) |
| U023 | Halogenated solvent | Laboratory wastes/ discarding of out-of-date chemicals | 2 G | 0 | 0 | Benzotrichloride(>90%) |
| U023 | Aqueous waste w/low other toxic organics | Cleanup of spill residues | 148748 G | 5 | 95 | N |
| U023(MIXED) | Cont. Soil or cleanup residue | Cleanup of spill residues | 1 T | 99 | 0 | N |
| U096(MIXED) | Other organic liquid | Discarding of out-of-date products or chemicals | 180 G | 5 | 95 | N |
| U096(MIXED) | Other "dry" ash,slag or thermal residue | Other pollution control or waste treatment process | 15 T | 95 | 5 | N |
| U096(MIXED) | Other "dry" ash,slag or thermal residue | Other pollution control or waste treatment process | 15 T | 95 | 5 | N |
| U096(MIXED) | Reactive organic solid | Other waste production process | 18 T | ND | ND | Methyl ethyl ketone peroxide(10-25%) |
| U098 | Other organic liquid/contaminated off-spec or discarded product | Discarding of out-of-date products or chemicals | 1 T | DK | DK | 1,2-Dimethylhydrazine(>90%) |
| U098 | Nonhalogenated solvent | Laboratory wastes/ discarding of out-of-date chemicals | 6 G | 0 | 0 | 1,1-Dimethylhydrazine(>90%) |
| U098 | Wastewater or aqueous mixture | Other waste production process | 44 T | 0 | 95 | 1,1-Dimethylhydrazine(0.1-1%),Methanol(1-10%) |
| U099 | Other organic liquid | Laboratory wastes | 1 G | 0 | 0 | 1,2-Dimethylhydrazine(10-25%) |
| U103 | Spent acid w/metals | Other process | 16360 G | ND | ND | N |
| U103 | Nonhalogenated solvent | Laboratory wastes/ discarding of out-of-date chemicals | 1 G | 0 | 0 | Dimethyl sulfate(>90%) |
| U103(MIXED) | Spent acid w/metals | Dip rinsing/electroplating | 110 G | 3 | 45 | N |
| U109 | Lab packs of old chemicals only | Laboratory wastes/ discarding of out-of-date chemicals | 1 G | 99 | 0 | 1,2-Diphenylhydrazine(>90%) |
| U133 | Reactive or polymerizable organic liquid/organic gases | Discarding of off-spec material | 1 T | NA | DK | N |
| U133 | Other organic liquid | Discarding of out-of-date products or chemicals | 220 G | 0 | 40 | Hydrazine(25-50%) |

Table A-2 (continued)

| WASTE CODE | WASTE DESCRIPTION | SOURCE OF WASTE GENERATION | QUANTITY | PERCENT SOLIDS | PERCENT WATER | CONSTITUENTS PRESENT IN PERCENTAGE LEVELS |
|---|---|---|---|---|---|---|
| U133 | Nonhalogenated solvent | Laboratory wastes/ discarding of out-of-date chemicals | 1 G | 0 | 0 | Hydrazine(>80%) |
| U133 | Concentrated off-spec or discarded product | Laboratory wastes/ discarding of out-of-date chemicals | 1 T | DK | DK | Hydrazine(>80%) |
| U133(MIXED) | Other aqueous waste with low dissolved solids | Discarding of out-of-date products or chemicals | 1 T | 0 | 80 | Hydrazine(10-25%) |
| U133(MIXED) | Nonhalogenated solvent | Reaction/synthesis media processing | 91 T | DK | DK | N |
| U133(MIXED) | Other organic liquid | Clean out of process equipment | 0 | DK | DK | N |
| U133(MIXED) | Empty or crushed metal drums or containers | Other waste production process | 0 | 99 | 1 | N |
| U133(MIXED) | Other inorganic liquid/aqueous waste with low | Accidental spills or discharges | ND | 0 | 0 | Hydrazine(>80%) |
| U133 (MIXED) | Wastewater or aqueous mixture | Clean out of process equipment/cleanup of spills | 521448 T | 1 | 99 | Methanol(500ppm-0.1%), |
| U133(MIXED) | Soil contaminated with organics only/inorganic gases | Cleanup of spill residues | 1 T | 100 | 0 | N |
| U133(MIXED) | Acidic aqueous waste | Discarding of off-spec materials/cleanup of spills | 595 G | 0 | 95 | Hydrazine(25-50%) |
| U133(MIXED) | Aqueous waste w/other reactives(explosives) | Accidental spills or discharges | 2 G | 0 | 95 | Hydrazine(25-50%) |
| U133(MIXED) | Other reactive salts/chemicals | Other waste production process/lab wastes | 82 G | 99 | 0 | Hydrazine(0.1-1%) |
| U133(MIXED) | Other organic liquid | Discarding of out-of-date products or chemicals | 0 | NA | 15 | Hydrazine(75-90%) |
| U133 (MIXED) | Other inorganic solids | Filtration/centrifuging | 3 T | 100 | NA | N |
| U133(MIXED) | Empty or crushed metal drums or containers | Other remedial action/cleanup | 0 | 99 | DK | N |
| U134 | Other untreated waste | Laboratory wastes | 100 G | 0 | 10 | Hydrogen fluoride(25-50%) |
| U134 | Other inorganic liquid | Discarding of off-spec material | 4 T | NA | NA | N |
| U134 | Other treatment residue | Other pollution control or waste treatment process | 40500 G | NA | 50 | N |
| U134 | Acidic aqueous waste | Other process | 880 T | 0 | 97 | N |
| U134 | Acidic aqueous waste | Other process | 132 G | DK | DK | N |
| U134 | Still bims of halogenated solvents or other organic liquids | Other process | 1285 G | DK | DK | DK |
| U134 (MIXED) | Spent acid without metals | Distillation and fractionation/heavy ends or still bottoms | 28710 G | P | P | N |
| U134 (MIXED) | Other l or k waste, as described | None | 300 G | DK | DK | N |
| U134 (MIXED) | Spent acid without metals | None | 550 G | DK | DK | Hydrogen fluoride(25-50%) |
| U134 (MIXED) | spent acid without metals | Other waste production process | 3400 G | P | P | N |
| U134 (MIXED) | Acidic aqueous waste | Other waste production process | 26615 G | 0 | 99 | Hydrogen fluoride(1-10%) |
| U134 (MIXED) | Mixed lab packs | Discarding of out-of-date products or chemicals | 1980 G | P | P | N |
| U134 (MIXED) | Empty fiber or plastic containers | Other one-time process | 18 G | 99 | 1 | Hydrogen fluoride(500ppm-0.1%) |
| U134 (MIXED) | Wastewater or aqueous mixture | Other cleaning or degreasing process/stripping | 12300 G | 0 | 99 | N |
| U134 (MIXED) | Other waste inorganic chemicals | Cleanup of spill residues | 1595 G | P | P | Hydrogen fluoride(1-10%) |
| U134 (MIXED) | Spent acid without metals | Stripping/clean out of process equipment | 180 G | 8 | 62 | Hydrogen fluoride(>80%) |
| U134 (MIXED) | Spent acid without metals | Other process | 23000 G | 0 | 74 | N |
| U134 (MIXED) | Other aqueous waste with low dissolved solids | Wastewater treatment | 997000 G | 1 | 99 | N |
| U134 (MIXED) | Other organic liquid | Laboratory wastes | 3 T | NA | NA | Hydrogen fluoride(1-10%),Chlorinated fluorocarbons,NOS(500ppm-0.1%) |
| U134 (MIXED) | Spent acid without metals | Pickling | 2000 G | 1 | 39 | N |
| U134 (MIXED) | Concentrated aqueous solution of other organics | Discarding of off-spec material | 1 T | DK | DK | N |
| U134 (MIXED) | Waste oil | Clean out of process equipment | 990 G | 0 | 1 | N |
| U134 (MIXED) | Empty or crushed metal drums or containers | Closure of process equipment | 15 T | 99 | 1 | N |
| U134 (MIXED) | Mixed lab packs | Laboratory wastes | 1 T | ND | ND | N |
| U134 (MIXED) | Mixed lab packs | Laboratory wastes | 1 T | ND | ND | ND |
| U134 (MIXED) | Apcd sludge/scrubber water | Flue gas desulfurization/other pollution control | ND | 1 | 98.5 | Hydrogen fluoride(500ppm-0.1%) |
| U135 | Inorganic gases | Combustion processes | 1136 T | 0 | DK | N |
| U135 | Concentrated off-spec or discarded product | Discarding of out-of-date products or chemicals | 1 T | DK | DK | N |
| U135 | Solidified treatment residue | Other pollution control or waste treatment process | 9 T | DK | DK | N |
| U135 | Inorganic gases | Laboratory wastes/ discarding of out-of-date chemicals | 0 | 0 | 0 | N |
| U135(MIXED) | Other inorganic liquid | Other waste production process | 224220 T | P | P | N |
| U135(MIXED) | Other waste inorganic chemicals | Discarding of out-of-date products or chemicals | 1 T | 50 | DK | N |
| U160 | Concentrated off-spec or discarded product | Other waste production process | 1 T | 0 | 0 | Methyl ethyl ketone peroxide(25-50%) |
| U189(MIXED) | Contaminated soil or cleanup residue | Closure of surface impoundments | 216000 G | 88 | 10 | N |

DK = DON'T KNOW
G = GALLONS
N = NONE LISTED
NA = NOT AVAILABLE
ND = NO DATA
P = PRESENT
T = TONS

REFERENCE: USEPA 1988a, Reference 7

Table A-3 Generation Information for Reactive U and P Wastes According to the 1986 TSDR Survey

| Waste code | EPA Region | State | SIC codes | Industry | Volume |
|---|---|---|---|---|---|
| P006-Aluminum phosphide | IV | SC | 3731/9711 | Ship building and repairing/ National security | 0.5T |
| P009-Ammonium picrate | | | | | |
| P015-Beryllium dust | II | NY | 7301 | | 3.0G |
| | III | MD | 3764 | Space propulsion units and parts | 24.0G |
| | | VA | 9711 | National security | 1.0T |
| | IV | FL | 9199/9711/ 3471/3721 | General government/national Security/plating and polishing/ Aircraft | 1.0T |
| | | SC | 3731/9711 | Ship building and repairing/ national security | 3.0T |
| | V | OH | 3641 | Electric lamps | 1.0P |
| | VI | TX | 3483/2892 | Ammunition, except for small arms/explosives | 8.0T |
| | VIII | CO | 3761/3764/ 7391/3769 | Guided missiles and space vehicles/space propulsion units and parts research and development laboratories/space vehicle equipment | 660.0G, 18.0T |
| | IX | CA | 3679/9661/ 2999 | Electronic components/space research and technology/petroleum and coal products | 1.0T |
| | | | 3629/3832/ 3671/3693 | Electrical industrial apparatus/ optical instruments and lenses/ electron tubes, receiving type/ x-ray apparatus and tubes | 27.0T |
| | | | 3761 | Guided missiles and space vehicles | 1.0G |
| | | | 3699 | Electrical equipment and supplies | 1608.0G |
| | X | WA | 9711/8922/ 4911/1541 | National security/noncommercial research organizations/electric services/industrial buildings and warehouses | 1.0T |
| P056-Fluorine | II | NJ | 2869/2833 | Industrial organic chemicals/ medicinals and botanicals | 1.0T |
| P068-Methyl hydrazine | III | DE | 2800 | General chemical manufacturing | 831.0P |
| | V | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |
| | VI | NM | 9661 | Space research and technology | 30,000G |
| P073-Nickel carbonyl | III | DE | 2800 | General chemical manufacturing | 1.0P |
| P081-Nitroglycerin | | | | | |

Table A-3 (Continued)

| Waste code | EPA Region | State | SIC codes | Industry | Volume |
|---|---|---|---|---|---|
| P087-Osmium tetroxide | III | DE | 2800 | General chemical manufacturing | 1.5P |
| | | PA | 2647/2611 | Sanitary paper products/pulp mills | 1.0P |
| | IV | NC | 9199 | General government | 1.0T |
| | V | IL | 8221/2800/ 8071/2833 | Colleges and universities/ general chemical manufacturing/ medical laboratories/medicinals and botanicals | 161.0G |
| | | OH | 7391 | Research and development | 1.0G |
| | | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |
| | VI | TX | 8062/8071 | General medical and surgical hospitals/medical laboratories | 64.0P |
| | VIII | MO | 8221/8062 | Colleges and universities/general medical and surgical hospitals | 1.0T |
| P096-Phosphine | V | MN | 8922/9199 | Noncommercial research organizations/general government | 1.0G |
| | VI | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |
| P105-Sodium azide | I | CT | 2834 | | |
| | II | NJ | 2869/2819 | Industrial organic chemicals/ industrial organic chemicals | 1.0T |
| | | | 2800/2821/ 2869/2899 | General chemical manufacturing/ plastic materials and resins/ industrial organic chemicals/ chemical preparations | 1.0T |
| | | | 2834 | Pharmaceutical preparations | 1.0T |
| | | | 2899/2819/ 2869 | Chemical preparations/industrial inorganic chemicals/industrial organic chemicals/chemical preparations | 1.0T |
| | | | 2834/2831 | Pharmaceutical preparations/ biological products | 1.0T |
| | | NY | 2800 | General chemical manufacturing | 1.0T |
| | III | DE | 2899 | Chemical preparations | 1.0T |
| | | | 2800 | General chemical manufacturing | 61.0T |
| | | PA | 2833/2379 | Medicinals and botanicals/ agricultural chemicals | 2.0G |
| | IV | NC | 9199 | General government | 1.0T |
| | V | OH | 2879/2869/ 2816/2819 | Agricultural chemicals/ industrial organic chemicals/ inorganic pigments/industrial inorganic chemicals | 10.0P |
| | | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |
| | VI | MO | 2869/2892/ 8911/3662 | Industrial organic chemicals/ explosives/engineering and | 1.0T |

Table A-3 (Continued)

| Waste code | EPA Region | State | SIC codes | Industry | Volume |
|---|---|---|---|---|---|
| P105-(continued) | | | | architectural services/radio and TV communication equipment | |
| | VI | MO | 8221/8062 | Colleges and universities/ general medical and surgical hospitals | 1.0T |
| | | TX | 8062/8071 | General medical and surgical hospitals/medical laboratories | 77.0P |
| | X | WA | 9711/8922/ 4911/1541 | National security/noncommercial research organizations/electric services/industrial buildings and warehouses | 5.0P |
| P112-Tetranitromethane | | | | | |
| P122-Zinc phosphide (>10%) | V | OH | 3641 | Electric lamps | 1.0P |
| U023-Benzotrichloride | II | NY | 2800/2812 2819/2869 | General chemical manufacturing/ alkalies and chlorine/industrial inorganic chemicals/industrial organic chemicals | 626.0T |
| U086-N,N-Diethylhydrazine | V | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |
| U096-a,a-Dimethyl(benzyl hydroperoxide) | | | | | |
| U098-1,1-Dimethylhydrazine | II | NJ | 2899/2819/ 2869 | Chemical preparations/industrial inorganic chemicals/industrial organic chemicals | 1.0T |
| | V | OH | 7391 | Research and development laboratories | 1.0G |
| | | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |
| U099-1,2-Dimethylhydrazine | | | | | |
| U103-Dimethyl sulfate | I | MA | 4226/4959/ 2899 | Special warehousing and storage/ sanitary services/chemical preparation | 12.0G |
| | II | NY | 7301 | | 2.0G |
| | III | DE | 2800 | General chemical manufacturing | 1.0P |
| | IV | NC | 9199 | General government | 1.0G |
| | V | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |

Table A-3 (Continued)

| Waste code | EPA Region | State | SIC codes | Industry | Volume |
|---|---|---|---|---|---|
| U109-1,2-Diphenylhydrazine | V | MI | 2869/2879 | Industrial organic chemicals/ agricultural chemicals | 5.0T |
| | | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.0G |
| U133-hydrazine | I | CT | 2834 | Pharmaceutical preparations | 2.0T |
| | | MA | 4226/4959/ 2899 | Special warehousing and storage/ sanitary services/chemical preparations | 55.0G |
| | II | NJ | 7391 | Research and development laboratories | 1.0G |
| | III | DE | 2800 | General chemical manufacturing | 17.0P |
| | IV | FL | 9661 | Space research and technology | 18.5T |
| | | NC | 9199 | General government | 1.0G |
| | | SC | 3731 | Ship building and repairing | 2.0T |
| | V | OH | 7391 | Research and development laboratories | 5.0G |
| | | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 110.0G |
| | | | 2869/2843/ 2899/2841 | Industrial organic chemicals/ surface active agents/chemical preparations/soap and other detergents | 26.0G |
| | VI | LA | 2869/2819 | Industrial organic chemicals/ industrial inorganic chemicals | 4.0T |
| | | TX | 8062/8071 | General medical and surgical hospitals/medical laboratories | 28.0P |
| | VIII | CO | 9711/3499 | National security/fabricated metal products | 1.0G |
| | | CO | 3761/3764/ 7391/3769 | Guided missiles and space vehicles/ space propulsion units and parts/ research and development laboratories/space vehicle equipment | 22.0T |
| | IX | CA | 3679/9661/ 2999 | Electronic components/space research and technology/ petroleum and coal products | 1.0T |
| | X | WA | 9711/3731 | National security/ship building | 1.0T |
| | | | 9711/8922/ 4911/1541 | National security/noncommercial research organizations/electric services/industrial buildings and warehouses | 446.0P |

Table A-3 (Continued)

| Waste code | EPA Region | State | SIC codes | Industry | Volume |
|---|---|---|---|---|---|
| U134-hydrogen fluoride | IX | CA | 3629/3832 | Electrical industrial apparatus/ | 41006 |
| | | | 3671/3693 | Optical instruments and lenses/ electron tubes, receiving type X-ray apparatus and tubes | |
| | | | 3999 | Manufacturing industries | 57T/35006 |
| | | | 3674 | Semiconductors and related devices | 527T |
| | III | DE | 2800 | General chemical manufacturing | 8.0P |
| | V | IN | 3674/3651/ | Semiconductors and related | 44670T |
| | | | 3471/3469 | devices/radio and TV receiving sets/electron tubes, receiving type/metal stampings | |
| | I | MA | 4226/4959 | Special warehousing and storage/ | 556 |
| | | | 2899 | Sanitary services/chemical preparations | |
| | V | MN | 2821/2641/ | Plastics, materials and resins/ | 12656 |
| | | | 3861/2851 | paper coating and glazing/ photographic equipment and Supplies/paints and allied products | |
| | VIII | MT | 2911 | Petroleum refining | 3.0T |
| | V | OH | 9711/3721 | National security/aircraft | 1.0T |
| | | | 7391 | research and development laboratories | 1.06 |
| | | | 3229/3471 | Pressed and blown glass/ Plating and polishing | 4,800,006 |
| | | | 3641 | Electric lamps | 1.0P |
| | III | PA | 2819/2873 | Adhesives and sealants/ | 55.06 |
| | | | 2869 | Nitrogenous fertilizers Industrial organic chemicals | |
| U134-hydrogen fluoride | VI | TX | 2869/2821 | Industrial organic chemicals/ | 15.06 |
| | | | 2899 | plastics, materials and resins/ Chemical preparations | |
| | X | WA | 9711/8922 | National security/noncommercial | 67.0P |
| | | | 4911/1541 | research organizations/electric services/industrial buildings and warehouses | |
| | V | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.06 |

Table A-3 (Continued)

| Waste code | EPA Region | State | SIC codes | Industry | Volume |
|---|---|---|---|---|---|
| U135-Hydrogen sulfide | I | MA | 3861 | Photographic equipment and supplies | 1500.06 |
| | III | DE | 2800 | General chemical manufacturing | |
| | IV | SC | 3751/9711 | Motorcycles, bicycles, and parts/ national security | 2.0T |
| | V | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.06 |
| | IX | CA | 2911 | Petroleum refining | 1.0T |
| U160-Methyl Ethyl ketone peroxide | II | NJ | 2834 | Pharmaceutical preparations | 1320.06 |
| | | NY | 2869 | Industrial organic chemicals | 17.0T |
| | IV | FL | 9661 | Space research and technology | 1.0T |
| | | SC | 3731/9711 | Ship building and repairing/ national security | 1.0T |
| | V | WI | 2800/2869 | General chemical manufacturing/ industrial organic chemicals | 1.06 |
| | VI | LA | 3764/3471/ 3499/3479 | Space propulsion units and parts/ plating and polishing/fabricated metal products/metal coating and allied services | 1.0T |
| | IX | CA | 2869 | Industrial organic chemicals | 1.5T |
| | X | WA | 9711/3731 | National security/ship building and repairing | 4.06 |
| U186-1,3-Pentadiene | | | | | |
| U189-Phosphorus sulfide | V | IL | 2869/2818/ 2819 | Industrial organic chemicals/ organic pesticide products/ industrial inorganic chemicals | 90.0T |
| | VI | TX | 2869/2821/ 2899 | Industrial organic chemicals/ plastics, materials, and resins/ chemical preparations | 1.06 |
| | VII | MO | 2879/2818 | Agricultural chemicals/organic pesticides products | 3.0T |
| | X | WA | 3721 | Aircraft | 1.0T |
| U249-Zinc phosphide (<10%) | IX | CA | 9199/2899 | General government/chemical preparations | 1.0T |

G = gallons
P = pounds
T = tons

Note: The default unit for the survey is tons.

Reference: USEPA 1986, Reference 8.

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Table A-4 Analytical Problems Associated with the Listing Constituents for Reactive P and U Waste Codes

| Chemical | CAS no. | Reasons for analytical problems |
|---|---|---|
| P006 - Aluminum phosphide | 20859738 | 5 |
| P009 - Ammonium picrate | 131748 | 3 |
| P056 - Fluorine | 7782414 | 5 |
| P068 - Methyl hydrazine | 60344 | 5 |
| P073 - Nickel carbonyl | 13463393 | 5 |
| P081 - Nitroglycerine | 55630 | 2 |
| P087 - Osmium tetroxide | 20816120 | 1 |
| P096 - Phosphine | 7803512 | 3 |
| P105 - Sodium azide | 26628228 | 3 |
| P107 - Strontium sulfide | 1314961 | 1 |
| P112 - Tetranitromethane | 509148 | 5 |
| P122 - Zinc phosphide (>10%) | 1314847 | 5 |
| U023 - Benzotrichloride | 98077 | 5 |
| U086 - 1,2-Diethylhydrazine | 1615801 | 4 |
| U096 - a,a-Dimethylbenzylhydroperoxide | 80159 | 3 |
| U098 - 1,1-Dimethylhydrazine | 57147 | 5 |
| U099 - 1,2-Dimethylhydrazine | 540738 | 5 |
| U103 - Dimethyl sulfate | 77781 | 5 |
| U133 - Hydrazine | 302012 | 3 |
| U134 - Hydrogen fluoride | 7664393 | 5 |
| U135 - Hydrogen sulfide | 7783064 | 5 |
| U160 - Methyl ethyl ketone peroxide | 1338234 | 5 |
| U186 - 1,3-pentadiene | 504609 | 3 |
| U189 - Phosphoric sulfide | 1314803 | 2 |
| U249 - Zinc phosphide (<10%) | 1314847 | 5 |

1. This constituent can be analyzed for the metal but not the inorganic compounds. It is the compound that gives the waste its reactive characteristic; therefore, EPA believes that a numerical standard based on metal content of the residuals may not control the reactive characteristic of the waste.

2. Only high performance liquid chromatography (HPLC) techniques have been identified for analysis of this constituent. This method, SW-864 Method 8310, is used to determine the concentration of certain polynuclear aromatic hydrocarbons (PAHs) in ground water and wastes. Use of this method presupposes a high expectation of finding the specific compounds of interest; if this method is used to screen samples for any or all of the applicable PAHs listed under the method, the analyst must develop protocols to verify the identity of those constituents. This inability to positively identify chemicals in a complex matrix is typical of methods that employ HPLC and limits the usefulness of such methods when analyzing complex samples containing unknown constituents.

3. The Agency knows of no methods that are available for analysis of this constituent.

4. Standards are not readily available for this constituent. Analytical standards are chemical compounds of guaranteed purity that can be used for calibrating instruments and checking the accuracy of the data. The Agency considers analytical standards for a constituent to be commercially unavailable if no chemical manufacturer or other supply sources will sell reasonably pure samples of that constituent to analytical laboratories. Without using a standard for a particular constituent, the analyst cannot ascertain that the analytical results for that constituent are reproducible. If the results are not reliable and reproducible, the ensuing numerical treatment standards are fallible and unenforceable.

5. This constituent decomposes in or reacts with water. When placed in water, some constituents separate into ions, while others decompose or react with the water. Such constituents are considered unstable in water. This instability inhibits or even prevents the direct measure of a constituent's concentration in aqueous wastes, treatment residues, and leaching solutions from such wastes.

Reference: Alchowiak 1989, Reference 9.

# APPENDIX B

# CARBON ADSORPTION PERFORMANCE DATA

The purpose of this appendix is to discuss the applicability of carbon adsorption to wastewaters containing reactive listing constituents. The discussion is subdivided by waste type so that the reader can readily understand the types of reactive wastes to which this technology is applicable.

Carbon adsorption is generally applicable to organic compounds containing one or more polar groups. The following are the major classes of compounds for which applicability can be readily established (Hutton 1981, Reference 10). Table B-1 shows the amenability of typical organic compounds to activated carbon adsorption.

1. Amines and Aminic-Like Compounds

A considerable volume of information exists on the removal of ammonia and amines from wastewaters. Reactive constituents containing amino ($NH_2$, NH or N) groups should behave similarly to the amines already studied, such as dipropylamine and aniline. Compounds containing $NH_2$, NH, or N groups among the reactive wastes are as follows:

- Methyl hydrazine (P068)
- N N diethyl hydrazine (U086)
- 1,1 diethyl hydrazine (U098)
- 1,2 diethyl hydrazine (U099)
- 1,2 diphenyl hydrazine (U109)
- Hydrazine (U133)

For aromatic hydrazines, comparisons should be made with aniline. Di-n-propylamine should be used as a surrogate or the alkylamines and ammonia should be used as a surrogate for free hydrazine.

2. Nitrated Compounds

A very large volume of information exists on the removal of nitrated phenols, aromatics, and aliphates from wastewater using activated

carbon. Compounds containing nitro groups, which are reactive waste constituents, are as follows:

- Ammonium picrate (P009), which is ammonium salt or trinitrophenol (the dinitrophenols have been extensively studied)
- Tetranitromethane (P112)

Nitrate esters (i.e., nitroglycerin (P081)) are known to be treatable by carbon adsorption. The listed waste, K045, is spent carbon for treatment of wastewaters from production of nitrate ester and other nitrated explosives.

3. Other Polar Compounds

Acid, ester, ketone, and alcohol compounds removed from wastewater using activated carbon have been studied extensively (Belfort 1981, Reference 11). The following reactive wastes fit into one or more of these compound classes:

- Dimethyl sulfate (U103) is an ester.
- Dimethyl benzyl hydroperoxide (U096) and methyl ethyl ketone peroxide (U160) are both organo peroxides, which are structurally similar to alcohols.

Table B-1 Amenability of Typical Organic Compounds to Activated Carbon Adsorption

| Compound | Molecular weight | Aqueous solubility | Concentration | | Adsorbability | |
|---|---|---|---|---|---|---|
| | | | Initial ($C_o$) | Final ($C_s$) | g Compound/ g Carbon | Percent reduction |
| **Alcohols** | | | | | | |
| Methanol | 32.0 | -- | 1,000 | 964 | 0.007 | 3.6 |
| Ethanol | 46.1 | -- | 1,000 | 901 | 0.020 | 10.0 |
| Propanol | 60.1 | -- | 1,000 | 811 | 0.038 | 18.9 |
| Butanol | 74.1 | 7.7 | 1,000 | 466 | 0.107 | 53.4 |
| n-Amyl alcohol | 88.2 | 1.7 | 1,000 | 282 | 0.155 | 71.8 |
| n-Hexanol | 102.2 | 0.58 | 1,000 | 45 | 0.191 | 95.5 |
| Isopropanol | 60.1 | -- | 1,000 | 874 | 0.025 | 12.6 |
| Allyl alcohol | 58.1 | -- | 1,010 | 789 | 0.024 | 21.9 |
| Isobutanol | 74.1 | 8.5 | 1,000 | 581 | 0.084 | 41.9 |
| t-Butanol | 74.1 | -- | 1,000 | 705 | 0.059 | 29.5 |
| 2-Ethyl butanol | 102.2 | 0.43 | 1,000 | 145 | 0.170 | 85.5 |
| 2-Ethyl hexanol | 130.2 | 0.07 | 700 | 10 | 0.138 | 98.5 |
| **Amines** | | | | | | |
| Di-N-Propylamine | 101.2 | -- | 1,000 | 198 | 0.174 | 80.2 |
| Butylamine | 73.1 | -- | 1,000 | 480 | 0.103 | 52.0 |
| Di-N-Butylamine | 129.3 | -- | 1,000 | 130 | 0.174 | 87.0 |
| Allylamine | 57.1 | -- | 1,000 | 686 | 0.063 | 31.4 |
| Ethylenediamine | 60.1 | -- | 1,000 | 893 | 0.021 | 10.7 |
| Diethylenetriamine | 103.2 | -- | 1,000 | 706 | 0.062 | 29.4 |
| Diethanolamine | 105.3 | 95.4 | 996 | 722 | 0.057 | 27.5 |
| Triethanolamine | 149.1 | -- | 1,000 | 670 | 0.067 | 33.0 |
| Monoisopropanolamine | 75.1 | -- | 1,000 | 800 | 0.040 | 20.0 |
| Diisopropanolamine | 133.2 | 87 | 1,000 | 543 | 0.091 | 45.7 |
| **Aromatics** | | | | | | |
| Benzene | 78.1 | 0.07 | 416 | 21 | 0.080 | 95.0 |
| Toluene | 92.1 | 0.047 | 317 | 66 | 0.050 | 79.2 |
| Ethyl benzene | 106.2 | 0.02 | 115 | 18 | 0.019 | 84.3 |
| Phenol | 94 | 6.7 | 1,000 | 194 | 0.161 | 80.6 |
| Hydroquinone | 110.1 | 6.0 | 1,000 | 167 | 0.167 | 83.3 |
| Aniline | 93.1 | 3.4 | 1,000 | 251 | 0.150 | 74.9 |
| Styrene | 104.2 | 0.03 | 180 | 18 | 0.028 | -88.8 |
| Nitrobenzene | 123.1 | 0.19 | 1,023 | 44 | 0.196 | 95.6 |

Table B-1 (continued)

| Compound | Molecular weight | Aqueous Solubility | Concentration | | Adsorbability | |
|---|---|---|---|---|---|---|
| | | | Initial ($C_o$) | Final ($C_s$) | g Compound/ g Carbon | Percent reduction |
| **Esters** | | | | | | |
| Methyl acetate | 74.1 | 31.9 | 1,030 | 760 | 0.054 | 26.2 |
| Ethyl acetate | 88.1 | 8.7 | 1,000 | 495 | 0.100 | 50.5 |
| Propyl acetate | 102.1 | 2 | 1,000 | 248 | 0.149 | 75.2 |
| Butyl acetate | 116.2 | 0.68 | 1,000 | 154 | 0.169 | 84.6 |
| Primary amyl acetate | 130.2 | 0.2 | 985 | 119 | 0.175 | 88.0 |
| Isopropyl acetate | 102.1 | 2.9 | 1,000 | 319 | 0.137 | 68.1 |
| Isobutyl acetate | 116.2 | 0.63 | 1,000 | 180 | 0.164 | 82.0 |
| Vinyl acetate | | | | | | |
| Ethylene glycol mono-ethyl ether acetate | 132.2 | 22.9 | 1,000 | 342 | 0.132 | 65.8 |
| Ethyl acrylate | 100.1 | 2.0 | 1,015 | 226 | 0.157 | 77.7 |
| Butyl acrylate | 128.2 | 0.2 | 1,000 | 43 | 0.193 | 95.9 |
| **Ketones** | | | | | | |
| Acetone | 58.1 | -- | 1,000 | 782 | 0.043 | 21.8 |
| Methyl ethyl ketone | 72.1 | 26.8 | 1,000 | 532 | 0.094 | 46.8 |
| Methyl propyl ketone | 86.1 | 4.3 | 1,000 | 305 | 0.139 | 69.5 |
| Methyl butyl ketone | 100.2 | v.sl.sol. | 988 | 191 | 0.159 | 80.7 |
| Methyl isobutyl ketone | 100.2 | 1.9 | 1,000 | 152 | 0.169 | 84.8 |
| Methyl isoamyl ketone | 114.2 | 0.54 | 986 | 146 | 0.169 | 85.2 |
| Diisobutyl ketone | 142.2 | 0.05 | 300 | nil | 0.060 | 100.0 |
| Cyclohexanone | 98.2 | 2.5 | 1,000 | 332 | 0.134 | 66.8 |
| Acetophenone | 120.1 | 0.55 | 1,000 | 28 | 0.194 | 97.2 |
| Isophorone | 138.2 | 1.2 | 1,000 | 34 | 0.193 | 96.6 |
| **Organic Acids** | | | | | | |
| Formic acid | 46.0 | -- | 1,000 | 765 | 0.047 | 23.5 |
| Acetic acid | 60.1 | -- | 1,000 | 760 | 0.048 | 24.0 |
| Propionic acid | 74.1 | -- | 1,000 | 674 | 0.065 | 32.6 |
| Butyric acid | 88.1 | -- | 1,000 | 405 | 0.119 | 59.5 |
| Valeric acid | 102.1 | 2.4 | 1,000 | 203 | 0.159 | 79.7 |
| Caproic acid | 116.2 | 1.1 | 1,000 | 30 | 0.194 | 97.0 |
| Acrylic acid | 72.1 | -- | 1,000 | 355 | 0.129 | 64.5 |
| Benzoic acid | 122.1 | 0.29 | 1,000 | 89 | 0.183 | 91.1 |

Reference: Giusti, Conway, and Lawson 1974, Reference 12.

# APPENDIX C

## WASTEWATER TREATMENT PERFORMANCE DATA FOR FLUORIDE

## DATABASE KEY

| | |
|---|---|
| BDAT | Best Demonstrated Available Technology |
| ITD | Industrial Technology Division |
| NPDES | National Pollutant Discharge Elimination System |
| WAO | Wet Air Oxidation |
| WERL | Water Engineering Research Laboratory |
| OCPSF | Organic Chemicals, Plastics, and Synthetic Fibers |
| CMDB | Combined Metals Database |

KEY TO TREATMENT TECHNOLOGIES

AAS — Activated Alumina Sorption
AC — Activated Carbon
AFF — Aerobic Fixed Film
AL — Aerobic Lagoons
API — API Oil/Water Separator
AS — Activated Sludge
AirS — Air Stripping
AnFF — Anaerobic Fixed Film
AnL — Anaerobic Lagoons
BGAC — Biological Granular Activated Carbon
CAC — Chemically Assisted Clarification
Chem/Cond — Chemical Conditioning
ChOx — Chemical Oxidation (Parentheses shows oxidation chemical ie. ChOx (Oz) - is ozone)
ChOx/Pt — Chemical Oxidation/Precipitation
ChPt — Chemical Precipitation
Chred — Chemical Reduction
Chred/Pt — Chemical Reduction/Precipitation
CN/Ox — Cyanide Oxidation
COAG — Coagulation
DAF — Dissolved Air Flotation
Fil — Filtration
FLOAT — Floatation
GAC — Activated Carbon (Granular)
Gr/Rem — Grease/Oil Removal
KPEG — Dechlorination of Toxics using an Alkoxide (Formed by the reaction of potassium hydroxide with polyethylene glycol (PEG400))
IE — Ion Exchange
In-PB — In-Plant Biological Treatment
L — Lime
LL — Liquid, Liquid Extraction
Neut — Neutralization
PACT — Powdered Activated Carbon Addition to Activated Sludge
RBC — Rotating Biological Contactor
RO — Reverse Osmosis
SBR — Sequential Batch Reactor
SCOx — Super Critical Oxidation
SExt — Solvent Extraction
SS — Steam Stripping
Sed — Sedimentation
TF — Trickling Filter
UF — Ultrafiltration
UV — Ultraviolet Radiation
WOx — Wet Air Oxidation

NOTES:

____ + ____ is the first process unit followed in process train by the second ie. AS + Fil - Activated Sludge followed by Filtration.

____ w ____ is the two units together ie. UFwPAC - Ultrafiltration using Powdered Activated Carbon.

____ (B) is batch instead of continuous flow.

Fluoride. The data available for fluoride were compiled from the BDAT, WERL, and ITD databases. Demonstrated treatment technologies included AAS, ChPt, RO, L+Sed, and L+Sed+Fil. The technology size included bench, pilot, and full-scale data. The resulting effluent concentrations ranged from 200 ppb to 14,500 ppb.

The BDAT standard was set using L+Sed technology and an achievable effluent of 14,500 ppb. L+Sed was selected as BDAT since these data represent ITD full scale treatment performance data from the CMDB. L+Sed shows equivalent substantial treatment to L+Sed+Fil.

The resulting BDAT treatment standard for fluoride is 35,000 ppb as shown in Table 4-173.



TABLE
WASTEWATER TREATMENT PERFORMANCE DATA
FOR FLUORIDE

| TECHNOLOGY | TECHNOLOGY SIZE | FACILITY | DETECTION LIMIT (ppb) | RANGE INFLUENT CONCENTRATION (ppb) | NO. OF DATA POINTS | AVERAGE EFFLUENT CONCENTRATION (ppb) | RECOVERY (%) | REMOVAL (%) | REFERENCE |
|---|---|---|---|---|---|---|---|---|---|
| AAS | Full | 1284B | | 10000-100000 | | 200,000 | | 98.8 | WERL |
| AAS | Full | 1284B | | 1000-10000 | | 200,000 | | 95.2 | WERL |
| ChPt (B) | Bench | 1313E | | 1000-10000 | | 300,000 | | 92.5 | WERL |
| L+Sed | Full | | | | | 14500,000 | | | ITD-CMDB |
| L+Sed+Fil | Full | | | | | 14500,000 | | | ITD-CMDB |
| LL+SS+AC | Full | K103/K104 | | 200 | 4 | 482,000 | | | BDAT |
| RO | Pilot | 180A | | 100-1000 | 18 | 210,000 | | 74 | WERL |
| RO | Full | 1284B | | 1000-10000 | | 600,000 | | 66 | WERL |
| RO | Full | 1284B | | 1000-10000 | | 600,000 | | 66 | WERL |

TABLE 4-173

BDAT TREATMENT STANDARDS FOR WASTEWATERS

| CONSTITUENTS | LONG TERM AVG. (PPB) | ACF | VF | BDAT TRT. STANDARD (PPB) |
|---|---|---|---|---|
| N-Nitrosomorpholine | 73 | 1.42 | 2.8 | 290 |
| N-Nitrosopiperidine | 2.4 | 1.42 | 2.8 | 10 |
| n-Nitrosopyrrolidine | 2.4 | 1.42 | 2.8 | 10 |
| 5-Nitro-o-toluidine | 58 | 1.42 | 2.8 | 230 |
| Pentachlorobenzene | 10 | 1.42 | 2.8 | 40 |
| Pentachloroethane | 10 | 1.42 | 2.8 | 40 |
| Pentachloronitrobenzene | 10 | 1.42 | 2.8 | 40 |
| Pentachlorophenol | 20 | 1.47 | 2.8 | 82 |
| Phenacetin | 2400 | 1.42 | 2.8 | 9542 |
| Phenanthrene | 10 | NA | 5.89125 | 59 |
| Phenol | 10.383 | NA | 2.49705 | 26 |
| Phthalic anhydride | 5 | 1.42 | 2.8 | 20 |
| Pronamide | 21 | 1.42 | 2.8 | 83 |
| Pyrene | 11.333 | NA | 5.89125 | 67 |
| Resorcinol | 5.5 | 2.7 | 2.8 | 42 |
| Safrole | 2400 | 1.42 | 2.8 | 9542 |
| 1,2,4,5-Tetrachlorobenzene | 10 | 1.42 | 2.8 | 40 |
| 2,3,4,6-Tetrachlorophenol | 6.8 | 2.7 | 2.8 | 51 |
| 1,2,4-Trichlorobenzene | 10 | 1.64 | 2.8 | 46 |
| 2,4,5-Trichlorophenol | 1 | 2.7 | 2.8 | 8 |
| 2,4,6-Trichlorophenol | 1 | 2.7 | 2.8 | 8 |
| Tris(2,3-dibromopropyl) phosphate | 20 | 1.42 | 2.8 | 80 |
| Acrylamide | 262 | 1.42 | 2.8 | 1042 |
| Antimony | 470 | NA | 4.1 | 1930 |
| Arsenic | 340 | NA | 4.1 | 1390 |
| Barium | 280 | NA | 4.1 | 1150 |
| Beryllium | 200 | NA | 4.1 | 820 |
| Cadmium | 49 | NA | 4.1 | 200 |
| Chromium(total) | 70 | NA | 5.28 | 370 |
| Copper | 390 | NA | 3.28 | 1280 |
| Lead | 80 | NA | 3.5 | 280 |
| Mercury | 38 | NA | 4.1 | 150 |
| Nickel | 220 | NA | 2.5 | 550 |
| Selenium | 200 | NA | 4.1 | 820 |
| Silver | 70 | NA | 4.1 | 290 |
| Thallium | 340 | NA | 4.1 | 1400 |
| Vanadium | 3 | 5 | 2.8 | 42 |
| Zinc | 230 | NA | 4.43 | 1020 |
| Cyanide | 180 | NA | 6.88 | 1200 |
| Fluoride | 14500 | NA | 2.41 | 35000 |
| Sulfide | 1000 | 5 | 2.8 | 14000 |
| Aldrin | 1.49 | 5 | 2.8 | 21 |
| alpha-BHC | 0.01 | 5 | 2.8 | 0.14 |
| beta-BHC | 0.01 | 5 | 2.8 | 0.14 |
| delta-BHC | 1.632 | 5 | 2.8 | 23 |
| gamma-BHC | 0.12 | 5 | 2.8 | 1.68 |
| Chlordane | 0.2338 | 5 | 2.8 | 3.27 |

# APPENDIX D

## PERFORMANCE DATA FOR STABILIZATION OF F006 WASTE

Table D-1 Performance Data for Stabilization of F006 Waste

| Constituent | Stream | Concentration (ppm) Sample Set # 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | Untreated total | - | - | - | - | - | - | - | - | - |
| | Untreated TCLP | <0.01 | <0.01 | <0.01 | - | <0.01 | <0.01 | <0.01 | <0.01 | 0.88 |
| | Treated TCLP[a] | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.02 |
| | Treated TCLP[b] | - | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.02 |
| Barium | Untreated total | 36.4 | 21.6 | 85.5 | 17.2 | 14.3 | 24.5 | 12.6 | 15.3 | 19.2 |
| | Untreated TCLP | 0.08 | 0.32 | 1.41 | 0.84 | 0.38 | 0.07 | 0.04 | 0.53 | 0.28 |
| | Treated TCLP[a] | 0.12 | 0.50 | 0.33 | 0.20 | 0.31 | 0.30 | 0.04 | 0.32 | 0.19 |
| | Treated TCLP[b] | - | 0.42 | 0.31 | 0.23 | 0.19 | 0.33 | 0.14 | 0.27 | 0.08 |
| Cadmium | Untreated total | 1.3 | 31.3 | 67.3 | 1.30 | 720 | 7.28 | 5.39 | 5.81 | 5.04 |
| | Untreated TCLP | 0.01 | 2.21 | 1.13 | 0.22 | 23.6 | 0.3 | 0.06 | 0.18 | 0.01 |
| | Treated TCLP[a] | 0.01 | 0.50 | 0.06 | 0.01 | 3.23 | 0.02 | 0.01 | 0.01 | <0.01 |
| | Treated TCLP[b] | - | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | <0.01 |
| Chromium | Untreated total | 1270 | 755 | 716 | 110 | 12200 | 3100 | 42900 | 47.9 | 644 |
| | Untreated TCLP | 0.34 | 0.76 | 0.43 | 0.18 | 25.3 | 38.7 | 360 | 0.04 | 0.01 |
| | Treated TCLP[a] | 0.51 | 0.40 | 0.08 | 0.23 | 0.25 | 0.21 | 3.0 | 0.10 | 0.03 |
| | Treated TCLP[b] | - | 0.39 | 0.20 | 0.30 | 0.38 | 0.76 | 1.21 | 0.2 | 0.21 |
| Copper | Untreated total | 40.2 | 7030 | 693 | 1510 | 160 | 1220 | 10600 | 17600 | 27400 |
| | Untreated TCLP | 0.15 | 368 | 1.33 | 4.6 | 1.14 | 31.7 | 8.69 | 483 | 16.9 |
| | Treated TCLP[a] | 0.20 | 5.4 | 1.64 | 0.30 | 0.20 | 0.21 | 0.40 | 0.50 | 3.18 |
| | Treated TCLP[b] | - | 0.25 | 1.84 | 0.27 | 0.29 | 0.20 | 0.42 | 0.32 | 0.46 |
| Lead | Untreated total | 35.5 | 409 | 25.7 | 88.5 | 52 | 113 | 156 | 169 | 24500 |
| | Untreated TCLP | 0.26 | 10.7 | 0.26 | 0.45 | 0.45 | 3.37 | 1.0 | 4.22 | 50.2 |
| | Treated TCLP[a] | 0.30 | 0.40 | 0.30 | 0.30 | 0.24 | 0.30 | 0.30 | 0.31 | 2.39 |
| | Treated TCLP[b] | - | 0.36 | 0.41 | 0.34 | 0.36 | 0.36 | 0.38 | 0.37 | 0.27 |

Table D-1 (Continued)

| Constituent | Stream | Concentration (ppm) Sample Set # 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mercury | Untreated total | - | - | - | - | - | - | - | - | - |
| | Untreated TCLP | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.003 | <0.001 | <0.001 | <0.001 |
| | Treated TCLP[a] | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| | Treated TCLP[b] | - | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Nickel | Untreated total | 435 | 989 | 259 | 37 | 701 | 19400 | 13000 | 23700 | 5730 |
| | Untreated TCLP | 0.71 | 22.7 | 1.1 | 0.52 | 9.78 | 730 | 152 | 644 | 16.1 |
| | Treated TCLP[a] | 0.04 | 1.5 | 0.23 | 0.10 | 0.53 | 16.5 | 0.40 | 15.7 | 1.09 |
| | Treated TCLP[b] | - | 0.03 | 0.15 | 0.02 | 0.04 | 0.05 | 0.10 | 0.04 | 0.02 |
| Selenium | Untreated total | - | - | - | - | - | - | - | - | - |
| | Untreated TCLP | <0.01 | <0.01 | <0.01 | - | <0.01 | <0.01 | <0.01 | <0.01 | <0.45 |
| | Treated TCLP[a] | 0.06 | 0.06 | 0.07 | 0.08 | 0.04 | 0.05 | 0.04 | 0.07 | <0.01 |
| | Treated TCLP[b] | - | 0.11 | 0.11 | 0.14 | 0.09 | 0.11 | 0.07 | 0.07 | <0.01 |
| Silver | Untreated total | 2.3 | 6.62 | 39 | 9.05 | 5.28 | 4.08 | 12.5 | 8.11 | 19.1 |
| | Untreated TCLP | 0.01 | 0.14 | 0.02 | 0.16 | 0.08 | 0.12 | 0.05 | 0.31 | <0.01 |
| | Treated TCLP[a] | 0.03 | 0.03 | 0.20 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | <0.01 |
| | Treated TCLP[b] | - | 0.05 | 0.05 | 0.04 | 0.06 | 0.05 | 0.05 | 0.05 | <0.01 |
| Zinc | Untreated total | 1560 | 4020 | 631 | 90200 | 35900 | 27800 | 120 | 15700 | 322 |
| | Untreated TCLP | 0.16 | 219 | 5.41 | 2030 | 867 | 1200 | 0.62 | 650 | 1.29 |
| | Treated TCLP[a] | 0.03 | 36.9 | 0.05 | 32 | 3.4 | 36.3 | 0.02 | 4.54 | 0.07 |
| | Treated TCLP[b] | - | 0.01 | 0.03 | 0.04 | 0.03 | 0.04 | 0.02 | 0.02 | <0.01 |

Binding agent: cement kiln dust.

[a]Mix ratio is 0.2. The mix ratio is the ratio of the reagent weight to waste weight.

[b]Mix ratio is 0.5.

Note: Waste samples are from the following industries: set #1, unknown; set #2, auto part manufacturing; set #3, aircraft overhauling; set #4, zinc plating; set #5, unknown; set #6, small engine manufacturing; set #7, circuit board manufacturing; set #8, unknown; and set #9, unknown.

Reference: CWM Technical Note 87-117, Table 1 (CWM 1987), Reference 13.

Table D-2 TCLP Performance Data for Stabilization of F006 Waste After Screening and Accuracy Correction of Treated Values

| Constituent | Stream | Concentration (ppm) Sample Set # 1[a] | 2[b] | 3[a] | 4[b] | 5[b] | 6[b] | 7[b] | 8[b] | 9[b] |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | Untreated TCLP | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | Treated TCLP | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Barium | Untreated TCLP | -- | -- | 1.41 | 0.84 | 0.38 | -- | -- | 0.53 | 0.28 |
| | Treated TCLP | -- | -- | 0.34 | 0.25 | 0.21 | -- | -- | 0.29 | 0.09 |
| Cadmium | Untreated TCLP | -- | 2.21 | 1.13 | 0.22 | 23.6 | 0.3 | 0.06 | 0.18 | -- |
| | Treated TCLP | -- | 0.01 | 0.06 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | -- |
| Chromium | Untreated TCLP | -- | 0.76 | 0.43 | -- | 25.3 | 38.7 | 360 | -- | -- |
| | Treated TCLP | -- | 0.45 | 0.09 | -- | 0.44 | 0.89 | 1.41 | -- | -- |
| Copper | Untreated TCLP | -- | 368 | -- | 4.6 | 1.14 | 31.7 | 8.69 | 483 | 16.9 |
| | Treated TCLP | -- | 0.27 | -- | 0.29 | 0.31 | 0.22 | 0.45 | 0.35 | 0.50 |
| Lead | Untreated TCLP | -- | 10.7 | -- | -- | -- | 3.37 | 1.0 | 4.22 | 50.2 |
| | Treated TCLP | -- | 0.39 | -- | -- | -- | 0.39 | 0.41 | 0.40 | 0.29 |
| Mercury | Untreated TCLP | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | Treated TCLP | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | Untreated TCLP | 0.71 | 22.7 | 1.1 | 0.52 | 9.78 | 730 | 152 | 644 | 16.1 |
| | Treated TCLP | 0.05 | 0.03 | 0.27 | 0.02 | 0.04 | 0.06 | 0.11 | 0.04 | 0.02 |
| Selenium | Untreated TCLP | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | Treated TCLP | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Silver | Untreated TCLP | -- | 0.14 | -- | 0.16 | -- | 0.12 | -- | 0.31 | -- |
| | Treated TCLP | -- | 0.06 | -- | 0.05 | -- | 0.06 | -- | 0.06 | -- |
| Zinc | Untreated TCLP | 0.16 | 219 | 5.41 | 2,030 | 867 | 1,700 | 0.62 | 650 | 1.29 |
| | Treated TCLP | 0.03 | 0.01 | .03 | 0.04 | 0.03 | 0.04 | 0.02 | 0.02 | 0.01 |

Binding agent: cement kiln dust.

[a]Mix ratio is 0.2. The mix ratio is the ratio of the reagent weight to waste weight.

[b]Mix ratio is 0.5.

Reference: CWM Technical Note 87-117, Table 1 (CWM 1987), Reference 13.

Table D-3 Matrix Spike Recovery Data for the TCLP Extracts from Stabilization of F006 Waste

| Constituent | Original amount found (ppm) | Duplicate (ppm) | % Error | Actual spike | % Recovery | Accuracy-correction factor |
|---|---|---|---|---|---|---|
| Arsenic | 0.101[a] | 0.01 | 0.0 | 0.086 | 94.5 | 1.06 |
| | 0.01[b] | 0.01 | 0.0 | 0.068 | 104 | 0.96 |
| Barium | 0.3737[a] | 0.3326 | 5.82 | 4.9474 | 91.9 | 1.09 |
| | 0.2765[b] | 0.222 | 10.9 | 5.1462 | 97.9 | 1.02 |
| Cadmium | 0.0075[a] | 0.0069 | 4.17 | 4.9010 | 97.9 | 1.02 |
| | 2.9034[b] | 0.7555 | 58.7 | 6.5448 | 94.3 | 1.06 |
| Chromium | 0.3494[a] | 0.4226 | 9.48 | 4.6780 | 85.8 | 1.17 |
| | 0.2213[b] | 0.2653 | 9.0 | 4.5709 | 86.6 | 1.15 |
| Copper | 0.2247[a] | 0.2211 | 0.81 | 4.8494 | 92.5 | 1.08 |
| | 0.1526[b] | 0.1462 | 2.14 | 4.9981 | 97.0 | 1.03 |
| Lead | 0.3226[a] | 0.3091 | 2.14 | 4.9619 | 92.9 | 1.08 |
| | 0.2142[b] | 0.2287 | 3.27 | 4.6930 | 89.4 | 1.12 |
| Mercury | 0.001[a] | 0.001 | 0.0 | 0.0034 | 92 | 1.09 |
| | 0.001[b] | 0.001 | 0.0 | 0.0045 | 110 | 0.91 |
| Nickel | 0.028[a] | 0.0264 | 6.87 | 4.5400 | 90.3 | 1.11 |
| | 0.4742[b] | 0.0859 | 69.3 | 4.6093 | 86.6 | 1.15 |
| Selenium[c] | 0.101[a] | 0.12 | 8.6 | 0.175 | 86 | 1.16 |
| | 0.043[b] | 0.053 | 10.4 | 0.095 | 66[d] | 0.96 |
| Silver[c] | 0.0437[a] | 0.0399 | 4.55 | 4.2837 | 84.8 | 1.18 |
| | 0.0344[b] | 0.0411 | 8.87 | 0.081 | 0.87[d] | 114.9 |
| Zinc | 0.0133[a] | 0.0238 | 28.3 | 5.0910 | 101.4 | 0.99 |
| | 27.202[b] | 3.65 | 76.3 | 19.818 | 87.8 | 1.14 |

[a]At a mix ratio of 0.5.
[b]At a mix ratio of 0.2.
[c]For a mix ratio of 0.2, correction factors of 1.16 and 1.18 were used when correcting for selenium and silver concentrations, respectively.
[d]This value is not considered in the calculation for the accuracy-correction factor.

Reference: Memo to R. Turner, U.S. EPA/HWERL from Jesse R. Conner, Chemical Waste Management, dated January 20, 1988.

Table D-4 Calculation of the Nonwastewater Treatment Standard for Nickel Treated by Stabilization

| Constituent | Concentration (ppm) Sample Set # 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean (mg/l) | Variability factor | Treatment standard (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BDAT Metals | | | | | | | | | | | | |
| Nickel | | | | | | | | | | | | |
| Accuracy-corrected treated TCLP | 0.05 | 0.03 | 0.27 | 0.02 | 0.04 | 0.06 | 0.11 | 0.04 | 0.02 | 0.072 | 4.47 | 0.32 |

# APPENDIX E

## PERFORMANCE DATA FOR CHEMICAL OXIDATION OF A METAL-BEARING WASTEWATER

Table E-1 Performance Data for Chemical Oxidation and Sludge Filtration of a Metal-Bearing Wastewater Sampled by EPA

| Constituent/parameter | Concentration (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sample Set #1 | | Sample Set #2 | | Sample Set #3 | | Sample Set #4 | |
| | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate |
| **BDAT Metals** | | | | | | | | |
| Antimony | <10 | <1 | <10 | <1 | <10 | <1 | <10 | - |
| Arsenic | <1 | <0.1 | <1 | <0.1 | <1 | <0.1 | <1 | <1 |
| Barium | <10 | <1 | <10 | <1 | <10 | 3.5 | <10 | <10 |
| Beryllium | <2 | <0.2 | <2 | <0.2 | <2 | <0.2 | <2 | <2 |
| Cadmium | 13 | <0.5 | 10 | <0.5 | <5 | <0.5 | <5 | <5 |
| Chromium (hexavalent)[a] | 893 | 0.011 | 807 | 0.190 | 775 | -[a] | 0.6 | 0.042 |
| Chromium (total) | 2,581 | 0.17 | 2,279 | 0.12 | 1,990 | 0.20 | 556 | 0.10 |
| Copper | 138 | 0.21 | 133 | 0.15 | 133 | 0.21 | 88 | 0.07 |
| Lead | 64 | <0.01 | 54 | <0.01 | <10 | <0.01 | <10 | <0.01 |
| Mercury | <1 | <0.1 | <1 | <0.1 | <1 | <0.1 | <1 | <1 |
| Nickel | 471 | 0.33 | 470 | 0.33 | 16,330 | 0.33 | 6,610 | 0.33 |
| Selenium | <10 | <1 | <10 | <1 | <10 | <1 | <10 | <10 |
| Silver | <2 | <0.2 | 2 | <0.2 | <2 | <0.3 | <2 | <2 |
| Thallium | <10 | <1 | <10 | <1 | <10 | <1 | <10 | <10 |
| Zinc | 116 | 0.125 | 4 | 0.115 | 3.9 | 0.140 | 84 | 1.62 |
| **Other Parameters** | | | | | | | | |
| Total organic carbon | 2700 | | 2800 | | 500 | | 2900 | |
| Total solids | - | | - | | - | | - | |
| Total chlorides | - | | - | | - | | - | |
| Total organic halides | 2500 | | 3600 | | 0 | | 900 | |

Table E-1 (continued)

| Constituent/parameter | Concentration (ppm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sample Set #5 | | Sample Set #6 | | Sample Set #7 | | Sample Set #8 | |
| | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate |
| **BDAT Metals** | | | | | | | | |
| Antimony | <10 | <1 | <10 | <1 | <10 | <1 | <10 | <1 |
| Arsenic | <1 | <0.1 | <1 | <0.1 | <1 | <0.1 | <1 | <0.1 |
| Barium | <10 | <1 | <10 | <2 | <10 | <1 | <10 | <1 |
| Beryllium | <2 | <0.2 | <2 | <0.2 | <2 | <0.2 | <2 | <0.2 |
| Cadmium | <5 | <0.5 | <5 | <0.5 | 10 | <0.5 | <5 | <0.5 |
| Chromium (hexavalent) | 917 | 0.058 | 734 | -[a] | 769 | 0.121 | 0.13 | <0.01 |
| Chromium (total) | 2,236 | 0.11 | 2,548 | 0.10 | 2,314 | 0.12 | 831 | 0.15 |
| Copper | 91 | 0.14 | 149 | 0.12 | 72 | 0.16 | 217 | 0.16 |
| Lead | 18 | <0.01 | <10 | <0.01 | 108 | <0.01 | 212 | <0.01 |
| Mercury | 1 | <0.1 | <1 | <0.1 | <1 | <0.01 | <1 | <0.1 |
| Nickel | 1,414 | 0.310 | 588 | 0.33 | 476 | 0.40 | 669 | 0.36 |
| Selenium | <10 | <1 | <10 | <1 | <10 | <1 | <10 | <1 |
| Silver | <2 | <0.2 | <2 | <0.2 | <2 | <0.2 | <2 | <0.2 |
| Thallium | <10 | <1 | <10 | <1 | <10 | <1 | <10 | <1 |
| Zinc | 71 | 0.125 | 4 | 0.095 | 171 | 0.115 | 151 | 0.130 |
| **Other Parameters** | | | | | | | | |
| Total organic carbon | 200 | | 700 | | 3400 | | 5900 | |
| Total solids | - | | - | | - | | - | |
| Total chlorides | - | | - | | - | | - | |
| Total organic halides | 0 | | 700 | | 1900 | | 800 | |

Table E-1 (continued)

| Constituent/parameter | Concentration (ppm) | | | | | |
|---|---|---|---|---|---|---|
| | Sample Set #9 | | Sample Set #10 | | Sample Set #11 | |
| | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate | Treatment tank composite | Filtrate |
| **BDAT Metals** | | | | | | |
| Antimony | <10 | <1 | <10 | <1 | <10 | <1.00 |
| Arsenic | <1 | <0.1 | <1 | <0.1 | <1 | <0.10 |
| Barium | <10 | <1 | <10 | <1 | <12 | <1.00 |
| Beryllium | <2 | <0.2 | <2 | <0.2 | <2 | <0.20 |
| Cadmium | <5 | <0.5 | <5 | <0.5 | 23 | <5 |
| Chromium (hexavalent) | 0.07 | 0.041 | 0.08 | 0.106 | 0.30 | <0.01 |
| Chromium (total) | 939 | 0.10 | 395 | 0.12 | 617 | 0.18 |
| Copper | 225 | 0.08 | 191 | 0.14 | 137 | 0.24 |
| Lead | <10 | <0.01 | <10 | <0.01 | 136 | <0.01 |
| Mercury | <1 | <0.1 | <1 | <0.1 | <1 | <0.10 |
| Nickel | 940 | 0.33 | 712 | 0.33 | 382 | 0.39 |
| Selenium | <10 | <1.0 | <10 | <1 | <10 | <1.00 |
| Silver | <2 | <0.2 | <2 | <0.2 | <2 | <0.2 |
| Thallium | <10 | <1.0 | <10 | <1 | <10 | <1.00 |
| Zinc | 5 | 0.06 | 5 | 0.070 | 135 | 0.100 |
| **Other Parameters** | | | | | | |
| Total organic carbon | 2100 | | 0 | | 52 | |
| Total solids | - | | - | | - | |
| Total chlorides | - | | - | | - | |
| Total organic halides | 0 | | <300 | | 300 | |

- = Not analyzed.

Note: Design and operating parameters are as follows:
pH during chromium reduction - 8.5 to 9.0.
Reducing agent - ferrous iron.
Ratio of reducing agent to hexavalent chromium - 3.2 to 10.
pH during chemical precipitation - 8 to 10.
Precipitation agent - lime.
Filter type - vacuum filter.

[a]Hexavalent chromium was actually treated by chromium reduction prior to chemical precipitation and sludge filtration.

Reference: USEPA 1986, Reference 14.

Table E-2 Accuracy-Corrected Data for Treated Wastewater Residuals from Chemical Oxidation and Sludge Filtration

| Constituent | Untreated concentration range[a] (mg/l) | Correction factor | Accuracy corrected concentration (mg/l) Sample Set # 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Antimony | <10 | 1/0.92 | (No substantial treatment) | | | | | | | | | | |
| Arsenic | <1 | 1/1.00 | (No substantial treatment) | | | | | | | | | | |
| Barium | <10 | 1/0.90 | <1.1 | <1.1 | <3.9 | <11 | <1.1 | <1.1 | <1.1 | <1.1 | <1.1 | <1.1 | <1.1 |
| Beryllium | <2 | 1/0.90 | (No substantial treatment) | | | | | | | | | | |
| Cadmium | <5-13 | 1/0.87 | <0.57 | <0.57 | <0.57 | <5.7 | <0.57 | <0.57 | <0.57 | <0.57 | <0.57 | <0.57 | <5.7 |
| Hexavalent chromium[b] | 0.08-893 | 1/1.06 | 0.010 | 0.179 | -[c] | 0.040 | 0.055 | -[c] | 0.114 | <0.009 | 0.039 | 0.100 | <0.009 |
| Chromium | 137-2581 | 1/0.68 | 0.176 | 0.176 | 0.294 | 0.147 | 0.162 | 0.147 | 0.176 | 0.221 | 0.147 | 0.176 | 0.265 |
| Copper | 72-225 | 1/0.83 | 0.253 | 0.181 | 0.253 | 0.084 | 0.169 | 0.145 | 0.193 | 0.193 | 0.096 | 0.169 | 0.289 |
| Lead | <10-212 | 1/0.76 | <0.013 | <0.013 | <0.013 | <0.013 | <0.013 | <0.013 | <0.013 | <0.013 | <0.013 | <0.013 | <0.013 |
| Mercury | ≤1 | 1/0.90 | (No substantial treatment) | | | | | | | | | | |
| Nickel | 382-16330 | 1/0.93 | 0.355 | 0.355 | 0.355 | 0.355 | 0.333 | 0.355 | 0.430 | 0.387 | 0.355 | 0.355 | 0.419 |
| Selenium | <10 | 1/0.48 | (No substantial treatment) | | | | | | | | | | |
| Silver | <2 | 1/0.76 | (No substantial treatment) | | | | | | | | | | |
| Thallium | <10 | 1/0.84 | (No substantial treatment) | | | | | | | | | | |
| Zinc | 3.9-171 | 1/0.98 | 0.128 | 0.117 | 0.143 | 1.653 | 0.128 | 0.097 | 0.117 | 0.133 | 0.061 | 0.071 | 0.102 |

[a]Untreated concentrations are not adjusted for accuracy.

[b]Hexavalent chromium was actually treated by chromium reduction prior to chemical precipitation and sludge filtration.

[c]Concentration could not be measured because of analytical interference.

Table E-3 Matrix Spike Recovery Data for Metals in Wastewater

| Constituent | Original sample (µg/l) | Spike added (µg/l) | Sample | | Duplicate | |
|---|---|---|---|---|---|---|
| | | | Spike result (µg/l) | Percent recovery[a] | Spike result (µg/l) | Percent recovery[a] |
| Antimony | <21 | 300 | 275 | 92 | 276 | 92 |
| Arsenic | <10 | 50 | 70 | 140 | 66 | 132 |
| Barium | 1,420 | 5,000 | 5,980 | 91 | 5,940 | 90 |
| Beryllium | 1.4 | 25 | 25 | 94 | 24 | 90 |
| Cadmium | 4.2 | 25 | 26 | 87 | 27 | 91 |
| Chromium | <4.0 | 50 | 35 | 70 | 34 | 68 |
| Copper | <4.0 | 125 | 107 | 86 | 104 | 83 |
| Lead | <5.0 | 25 | 22 | 88 | 19 | 76 |
| Mercury | <0.2 | 1.0 | 0.9 | 90 | 1.1 | 110 |
| Nickel | 203 | 1,000 | 1,140 | 94 | 1,128 | 93 |
| Selenium | <25 | 25 | 12 | 48 | <25 | NC |
| Silver | <4.0 | 50 | 42 | 84 | 38 | 76 |
| Thallium | <10 | 50 | 51 | 102 | 48 | 96 |
| Vanadium | <60 | 250 | 212 | 85 | 211 | 84 |
| Zinc | 2,640 | 10,000 | 12,600 | 100 | 12,400 | 98 |

NC = Not calculable.

[a]Percent recovery = [(spike result - original amount)/spike added] x 100.

Reference: USEPA 1988, Reference 15.

Table E-4 Calculation of the Treatment Standard for Nickel-Treated Wastewater

| Regulated constituent | Accuracy-corrected concentration | Mean | VF | Treatment standard total concentration (mg/l) |
|---|---|---|---|---|
| Nickel | 0.355 | 0.369 | 1.20 | 0.44 |
| | 0.355 | | | |
| | 0.355 | | | |
| | 0.355 | | | |
| | 0.333 | | | |
| | 0.355 | | | |
| | 0.430 | | | |
| | 0.387 | | | |
| | 0.355 | | | |
| | 0.355 | | | |
| | 0.419 | | | |